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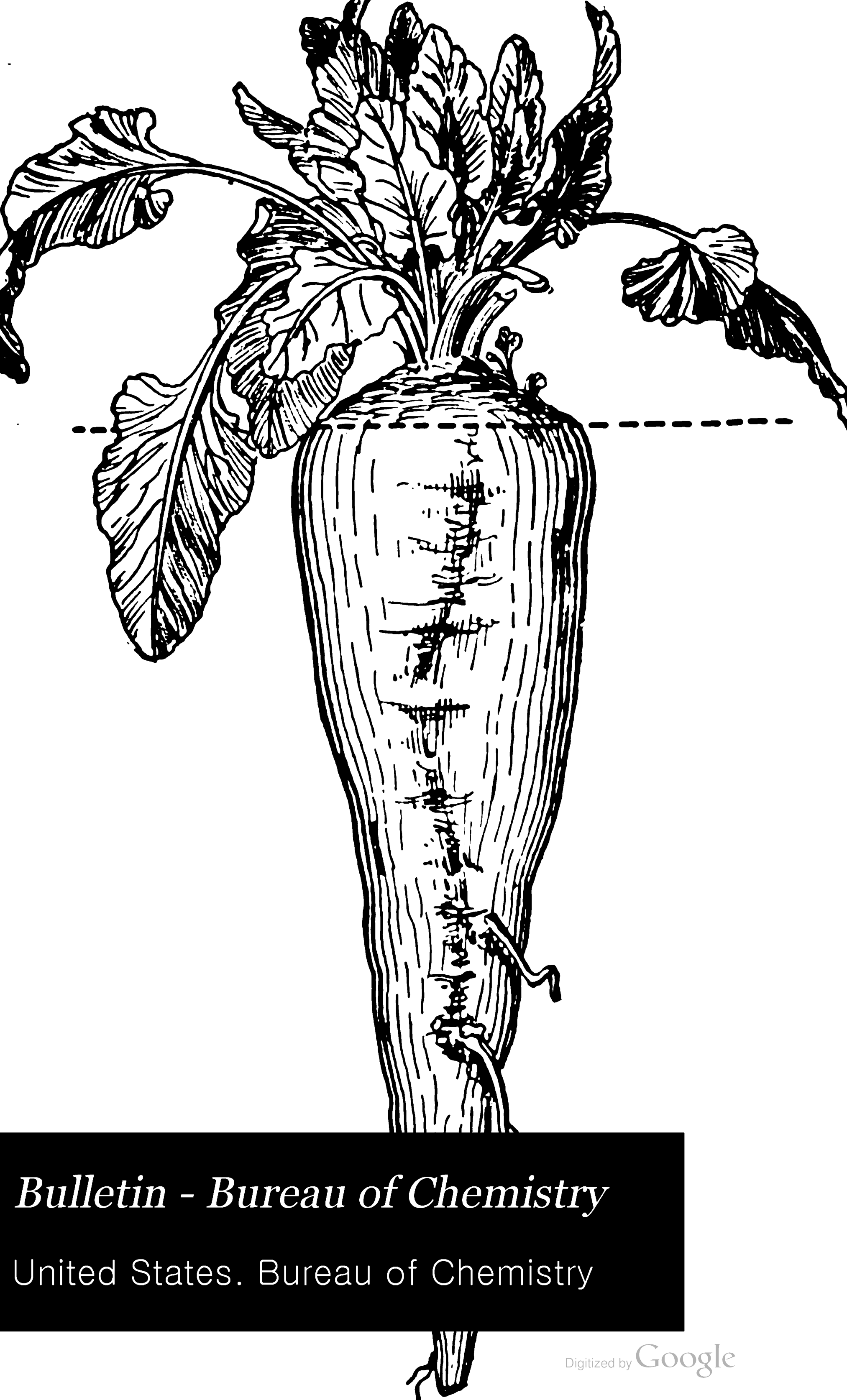

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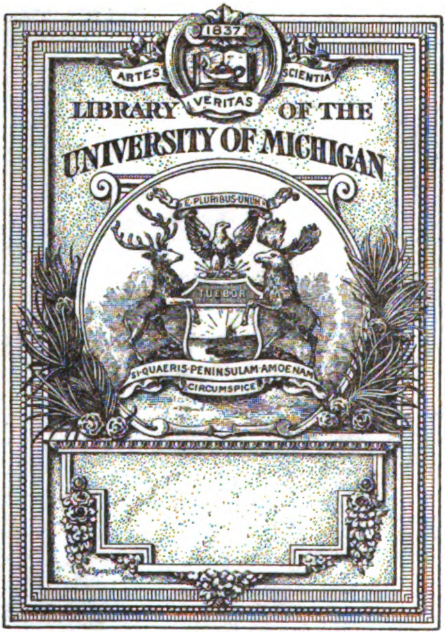
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BULLETIN No. 48.

U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF CHEMISTRY.

ZINC IN EVAPORATED APPLES.

BY

HARVEY W. WILEY,

CHIEF OF DIVISION OF CHEMISTRY.

WASHINGTON:
GOVERNMENT PRINTING OFFICE,
1896.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF CHEMISTRY,
Washington, D. C., February 14, 1896.

SIR: I have the honor to transmit herewith, for your inspection and approval, the manuscript of a report of an investigation in regard to the presence of zinc in American evaporated apples, undertaken by authority of the Assistant Secretary, and to recommend the publication of the same as Bulletin No. 48 of this Division.

Respectfully,

HARVEY W. WILEY,
Chief of Division of Chemistry.

Hon. J. STERLING MORTON,
Secretary of Agriculture.

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ZINC IN EVAPORATED APPLES.

The development of the evaporated fruit industry in this country has rendered available for export large quantities of evaporated apples. By reason of the modern improvements in the methods of evaporation, the desiccated apples retain to a remarkable degree their freshness and flavor. After preparation for the table, the evaporated fruits are scarcely distinguishable from their fresh state either in color or taste.

In the last few years many objections have been made in foreign countries to the use of evaporated fruits on account of their contamination with zinc. By reason of the complaints made by exporters and consular agents, the Secretary of Agriculture authorized an investigation to be made for the purpose of determining whether evaporated apples contain zinc, and if so, whether in quantities prejudicial to health.

INVESTIGATIONS AND ANALYSES HERETOFORE MADE.

In beginning this investigation a search was first made in the literature of the subject to find out what had been accomplished in the matter heretofore, and to learn the methods of investigation and analysis employed.

In 1886 a large number of samples of evaporated apples was examined by Prof. S. A. Lattimore, of Rochester, N. Y., and the report of his work was published in the Sixth Annual Report of the State Board of Health of New York. The samples collected by Dr. Lattimore were dried on galvanized iron trays. At that time, he states, it was the custom of the manufacturers to sulphur the apples after they were sliced, so that the surface of the slices saturated with sulphurous acid was brought into direct contact with the galvanized iron during the process of drying.

No traces of zinc were found in the samples examined by Professor Lattimore, and this seems strange in view of the experience of our own and other analysts. Nevertheless, it was noticed that the galvanized iron wires suffered oxidation and lost zinc. In a given sample of the wire cloth used in making the bottoms of the trays, 33 per cent of its weight of zinc was found. In another sample of the same cloth, used for three years, only 9 per cent of zinc was found. This shows a loss of 24 per cent of zinc, which, it is explained, was caused principally by mechanical means. Dr. Lattimore concludes that there can exist no well-founded cause of apprehension of any dangerous contamination of evaporated apples with zinc, and it is a matter of congratulation in the manufacture of an article of food so extensively used and likely to come into still more common use that there exists but slight possibility of the deterioration of the nutritive value of the product by the addition, incidentally or otherwise, of any foreign substance.

In the report of the dairy commissioner of New Jersey for 1890 occurs an article on dried apples by Professor Cornwall, of Princeton. Professor Cornwall analyzed 18 samples of dried apples purchased from dealers in various parts of New Jersey. Of this number 4 contained no zinc, in 2 traces of zinc were found, and in the other 12 were separated weighable quantities thereof. The largest percentage found was 0.18, and the smallest 0.002. In only one case out of the 18 is the amount of zinc sufficient to cause any suspicion. In the other cases, where zinc was present at all, its quantity was insignificant and wholly incapable of producing any poisonous effect whatever upon the organism.

Cornwall, in quoting from Lattimore's report (Report of the Dairy Commissioner of the State of New Jersey for 1889, p. 46), states that the apples in the process described by Lattimore are dried in an atmosphere of sulphurous acid derived from burning sulphur, the fruit being spread on screens of galvanized iron wire. This statement, however, does injustice to Lattimore's report, as will be seen further along.

SULPHURING APPLES—OBJECT.

While inspecting the processes used in the evaporation of apples in the principal factories in northwestern New York, in the autumn of 1895, it was observed that sulphuring in every instance was accomplished by exposing the apple, after the removal of the skin and core, to the action of the fumes of burning sulphur. The apples during this process are held on wooden trays, and in no observed case were they sliced béfore the sulphuring process. It is often stated that the sulphuring is accomplished after the apples have been sliced and placed upon the galvanized iron trays. If this ever was the custom, it has been abolished, and there seems to be no possibility from the manner in which the sulphuring is now accomplished of the process contributing in any way to increasing the amount of zinc present. The object of the sulphuring is twofold. In the first place, it prevents the darkening of the freshly-cut surface of the fruit. By reason of the oxidizing effects of the air the freshly cut surfaces of apples soon turn brown. The sulphuring prevents this and preserves the natural color of the fruit for a considerable period when exposed to the air. It might be supposed that the sulphuring of the whole apples before slicing would not be sufficient to preserve the fresh color of the surfaces after slicing. During the short time to which the apples are exposed to the fumes of burning sulphur, not exceeding, as a rule, half an hour, it might be supposed that the action of the sulphurous acid would be wholly superficial. Nevertheless, experience has shown that this method of procedure is quite sufficient to preserve the natural color of the slices and to prevent them from becoming dark during the process of evaporation. At the same time the quantity of sulphurous acid which is absorbed is not sufficient to in any way impair the flavor of the fruit nor to give it any odor of sulphurous acid when packed in boxes for shipment.

The second advantage which arises from sulphuring the fruit is in preventing the growth of insects in the evaporated product. While it is evident that the process of sulphuring is in no sense a sterilizing proceeding, yet it seems sufficient to prevent insects from depositing their eggs upon the evaporated slices, at least to a certain extent. Nevertheless, we have found insects in some of the samples collected for analysis. These insects have been studied by the Division of Entomology, and the following varieties have been identified: *Ephestia elutella*, *Ephestia interpunctella*, and *Silvanus surinamensis*. The first of these insects has not been previously known to infest dried apples, but it is commonly found in cacao beans, figs, and English walnuts.

As a further protection against insects in dried fruits, Hilgard states that the sulphuring is sometimes repeated after the evaporation. (California Agricultural Experiment Station, Bulletin 86.) This process, however, is to be condemned, because the dried fruit retains more persistently the sulphurous acid, which affects very seriously its flavor, giving to a freshly opened package the odor of burning sulphur, supplanting entirely the pleasant ethereal odor which the fruit should emit. According to Hilgard, the consumer has reason to object to the sulphuring of the dried fruit for two reasons, one of which is that the ill-prepared or damaged fruit which otherwise could not be sold is bleached and made presentable in market, and, second, that the flavor of the fruit is either seriously impaired or totally destroyed. Such a resulphured fruit contains also considerable quantities of the sulphurous acid, the excessive consumption of which may impair digestion and affect the health of the consumer. Finally, the excess of sulphurous acid in evaporated fruits becomes converted by gradual oxidation into sulphuric acid. The amount of sulphuric acid which has been found in such sulphured dried fruits is six times as great as that which occurs in unsulphured samples of the same variety. Hilgard suggests, as a substitute for sulphuring, dipping the sliced apples for a few minutes into a solution of salt containing about two ounces of common salt to five gallons of water. This process prevents any spotting where the fruit has been touched. Instead of the salt a similar solution of the bisulphites of soda or lime may be used, which effects a slight external bleaching without injury to the flavor of the fruit.

It is doubtless true that even the superficial bleaching to which the apples are subjected in the process of evaporation as now carried on, tends to increase, in a slight degree, the quantity of sulphuric acid in the ash of the evaporated fruit. It is not believed, however, that this increase is in any way prejudicial to health or objectionable from any point of view. It can not be denied that attractiveness of appearance does something more than merely please the eye in food products. The impression produced by food of an attractive appearance tends to stimulate the activity of the gastric cells and to promote in many ways the process of digestion. The fresh appearance of evaporated fruits secured by the moderate bleaching which has been described is, in my opinion, of value, and fully justifies the process. It is only when the bleaching is overdone, or when it has been applied in excess to fruits already discolored and dried, that it can be justly condemned.

The sulphuring process as described by Lattimore in 1886 (Sixth Annual Report of the State Board of Health of New York) was conducted as follows:

> The apples are pared, cored, and sliced by machines which are operated with great rapidity, either by hand or steam power. The slices, which are about half an inch thick, are placed in shallow trays or drawers which are transferred to a closed box, in the base of which a small quantity of sulphur is kept burning. The arrangement is such that a number of these trays may be introduced at the same time, one above the other, and all exposed to the fumes of burning sulphur as it circulates among them, finally escaping into the chimney. After being submitted to the sulphuring treatment, the slices are transferred to the drying screens, consisting of light rectangular wooden frames supporting the wire cloth, woven of iron wire coated with zinc.

This method, as has already been stated, has been superseded by the more modern one of applying the sulphur fumes before slicing.

PROCESS OF EVAPORATING FRUITS.

In the modern processes of manufacture the object has been to secure the fruit in an evaporated state as soon as possible after the commencement of operations upon it. It is not the purpose here to describe the drying kilns and the machinery by means of which the apples are prepared. Those interested in a study of modern drying kilns can find them fully described by Professor Bailey, in Bulletin 100, of the Cornell Agricultural Experiment Station. In four of the largest factories for the manufacture of evaporated fruits in northwestern New York the process as observed by personal inspection is conducted as follows:

The apples are pared and cored by machinery, after which they are placed in wooden trays with perforated bottoms and transferred to a wooden box which serves as a chimney for conducting off the fumes of burning sulphur. The arrangement of this box in some cases is quite ingenious. In one instance the trays are carried through a box, which lies in a horizontal position, by a slowly revolving continuous apron, consuming about twenty minutes in transit. In other instances different mechanical devices were noticed, but the process was essentially the same in all cases.

The sulphured apples are next passed to a slicing machine, in which the knives and other parts in contact with the fruit are made of bronze. By this machine they are cut into slices a little more than a quarter of an inch thick, each perfect slice having a circular perforation in the center caused by the previous removal of the core. It is this appearance of the slices which has given evaporated apples in Germany the common name "Ringäpfel." After slicing, the pieces are spread in thin layers on shallow trays of different sizes, made in every instance observed by me of galvanized iron wire. The slices should not be more than two deep, and in order to secure an even and uniform drying should not stick closely together. The trays, when filled, are transferred to large drying furnaces heated with steam or hot air, and the temperature and draft so regulated as to secure the required degree of desiccation in from three to four hours. It should be noted here that before beginning the operations above mentioned the apples are passed through screens, to separate them into grades of uniform size, and all decayed or injured fruit is removed. After the apples are pared they are again examined for decayed spots, and these, if not too large, are removed with a knife before the apples are sulphured and passed to the slicing machine.

After the trays are removed from the drying kilns the evaporated slices are removed and any imperfectly dried slices separated and thrown together for subsequent additional evaporation. In some instances I noticed that the trays were oiled from time to time, to prevent the evaporated slices from sticking thereto. The evaporated fruit is thrown into large heaps on a clean floor and allowed to remain for about two weeks, being occasionally turned over with a shovel. By this process the slices all acquire a uniform percentage of moisture. They are then sifted, so as to secure them in sizes of uniform dimensions, after which they are packed, usually with the help of pressure, into boxes suited for shipment, as a rule 50 pounds being placed in each box. The quantity of perfect fruit secured in an evaporated state is not far from 12 per cent of the gross weight of apples entering the manufactory. Cores and skins may be dried and used for flavoring jellies, etc., or they may be pressed for the purpose of cider making. In the latter case it is found that about one gallon of cider is secured for each bushel of apples used.

I am told that in many establishments, in order to avoid the danger of contaminating the evaporated fruit with zinc, trays are employed in which the bottoms are composed of wooden slats or canvas. The objection to the use of wood in the manufacture of the trays lies in the fact that the parts of the sliced apples lying in contact with the wood are imperfectly dried, so that the product is not of uniform nature. On the other hand, when evaporated apples are manufactured for the purpose of shipment abroad, to countries where sanitary inspection is exercised, the advantage of drying on wooden trays is manifest, allowing of a guarantee being given of the entire freedom of the product from zinc.

SUPERIORITY OF AMERICAN EVAPORATED FRUITS.

American evaporated apples, on account of their good taste and attractive appearance, are much preferred by the German public to the domestic product. Their consumption has also proved to be of advantage to the human body as a tonic aside from their nutritive value, and this is doubtless due to the iron they contain, which is probably derived from the machines used for cutting them. Many of the kinds which are found in commerce, however, have been found zinciferous, due to the zinc contained in the trays for holding them during drying. For several years, therefore, the Prussian, at the instance of the Hamburg authorities, have insisted upon having a certificate to the effect that the evaporated fruits offered for sale have not been dried in contact with galvanized iron wires. All the apples in a case will not be found adulterated, which comes from the fact that only the lower layers in the drying apparatus are brought in contact with the zinc. Niederstadt concludes from his examinations that it is very doubtful whether the evaporated fruit containing zinc is injurious to health, inasmuch as the content of zinc has been found in all cases a very small one, amounting in the largest quantities found to not more than seven-hundredths of 1 per cent. (Chemiker-Zeitung, vol. 19, p. 1757.) In his own family, where this fruit has been used for years, not the slightest injurious effect has ever been noticed. It is quite certain that the zinc which may be present in preserved fruits and vegetables coming from the solder should be far more an object of suspicion than that which is contained in evaporated apples.

RESTRICTIONS OF TRADE IN EVAPORATED APPLES.

In a few German cities the sale of American evaporated apples has been practically prohibited unless a certificate be furnished to the effect that they contain no zinc. By reason of this police regulation the trade has been very much injured and in some quarters almost destroyed. In so far as can be ascertained, no limits have been fixed in regard to the quantity of zinc which the evaporated fruit may contain, except as mentioned below, but all samples containing zinc are excluded from the trade. As an illustration of the character of the regulations in regard to the sale of the fruits, the action of the police authorities of Hamburg and Cologne may be cited.

DRIED APPLES AT HAMBURG.

In the report of W. Henry Robertson, United States consul at Hamburg, dated October 29, 1894, the following comments are made on the trade in American dried apples in Germany (Consular Report, 171, p. 89):

> I have ascertained in a semiofficial way that a movement is now being set on foot by the Imperial German Government, and is already engaging the attention of the authorities of this city and, I presume, of the other cities of the Empire, looking to the complete exclusion under the imperial law regarding the traffic in articles of food, etc., of May 14, 1879, of dried and evaporated apples from the United States which are found on arrival in Germany to contain more than a specified quantity of metallic zinc, arising from the drying of the apples on zinc plates or frames.
>
> Each locality determines for itself what quantity of zinc the apples consumed

therein can contain without being detrimental to health; but the tendency would seem to be to exclude the fruit when found to contain any zinc whatever. The laws of Hamburg prohibit the sale or offering for sale of apples having more than 0.01 per cent of metallic zinc. By metallic zinc is meant the actual amount of the metal left after separating the chemical combination of zinc and the acid of the apples.

For a number of years dried apples in the form of slices, pieces, or rings have been imported into Germany from the United States, and it has been observed that this fruit often contains zinc in such quantities that, according to medicinal authority, the consumption of the same may prove detrimental to health. The German authorities have, in consequence, since about five years ago endeavored by every possible means to prevent the importation of American dried fruits containing zinc and to bring about the judicial punishment of the venders of such merchandise.

In many cities, as, for instance, Hamburg, large quantities of American dried apples containing zinc have been confiscated by the police authorities or forcibly reexported. The courts have, in many cases, unequivocally decreed that the sale of dried apples containing zinc must be regarded as an offense against the German food law, in so far as the consumption of articles of food containing zinc shall be liable to injure human health.

The opinion of the medical authorities regarding the contents of zinc of the American dried apples is that the smallest quantities of zinc may lend articles of food qualities detrimental to health.

Of late the control of American dried apples in Germany has become more rigid, on account of an appeal of the German chancellor to the federated governments, requesting them to instruct the respective authorities to supervise the traffic in these goods, to have samples examined by food chemists, and, if found necessary, to lodge complaints against the sellers of goods injurious to health.

The sequel to these investigations is not unlikely to be the issuing of an order forbidding the sale in Germany of apples containing zinc.

There is no doubt that the American trade in dried apples would suffer severely through such a measure, and the only way for the purchasers of such goods to protect themselves against losses would be in the removal of the causes for the existence of zinc in the apples.

It is safe to assume that these causes are not attributable to any condition of the soil, but that the zinc gets into the apples during the drying process on zinc plates or frames, the acid of the apples chemically absorbing zinc.

Although by the employing of zinc plates or frames the dried apples retain a fine, light color, it would not seem to be advisable to employ such means for the sake of a comparatively small and purely external advantage.

Racks or frames of wood can be used just as well as those made of metal, or the apple slices might even be strung upon strings or cords. These methods are often employed in Germany, and, therefore, the brownish color of the products obtained through them would not put them to any disadvantage so far as their importation into Germany is concerned.

The above are almost the literal ideas of a gentleman here with whom I have conversed fully on this subject, and who has given me much valuable information.

While the object in making this report is to warn our exporters of dried fruit and other food products that it is all-important that, at this particular juncture, the articles sent by them to this country should be so prepared in every way as to offer no grounds for complaint on the part of either German officials or competing dealers here, such as might be successfully used to injure or destroy our trade, I do not feel disposed to admit, by any means, without further proof, the full extent of the alleged defects in our food products that are being claimed here.

Exporters who really send to this country unhealthy and inferior articles must and ought to expect disadvantages for their goods when competing with purer ones; but I feel convinced that our Government, upon the proper representations, will take all the necessary steps to protect the healthful and unadulterated wares of our exporters from unfair and unreasonable interference when offered for sale in the markets of Germany, and that it will use every means to prevent any restrictions being imposed upon them here, save such as are actually justifiable from a sanitary standpoint, and such as are applied to similar articles when produced here or imported from other countries than the United States.

DRIED APPLES AT COLOGNE.

In a report of William D. Wamer, the United States consul at Cologne, dated February 9, 1895, the text of an order warning the public against the consumption of American evaporated apples was given. The full report is as follows:

An order has just been issued by the police administration of Cologne and published in the local papers warning the public against eating sliced American dried apples. It says that large quantities of such apple slices, chiefly of American origin, are offered for sale here which contain a larger or smaller quantity of zinc. Of 13 samples selected for investigation, 11 are said to have contained zinc. It asserts, further, that the presence of zinc is due to the fact that the apple slices from America are not dried, as is done here, on wooden racks, but on zinc netting. By this process there is formed in the apples malate of zinc, which has an analogous operation to that of lactate of zinc. According to experts, the eating of such an article may undoubtedly be injurious to health, especially to children and those who have weak constitutions. Continuing, the mayor of the city says:

"I therefore feel obliged to give strict warning against the sale and the eating of American dried apple slices, and give notice to those offering such articles for sale that they will be proceeded against in accordance with the imperial law regulating the trade in food and food products."

There is a considerable trade in this market in American dried apples, and I am informed by an agent representing a large Chicago firm here that this order will frighten the public against eating such apples, and thereby injure, if not destroy altogether, this trade.

According to the statistics for the German Empire, there were imported into Germany from the United States in 1893, 2,968 tons, and in 1894, 2,133 tons of dried fruit, which I understand to be dried apple slices.

In a supplemental report of the same consul, dated February 11, 1895, attention is called to some modifications of the order, the nature of which will be indicated by the selections from the report given below:

Supplementary report.

Referring to my report forwarded to the Department of State under date of February 9, I have to report further that a number of the dealers here in American dried apple slices have since appealed to the mayor of Cologne to modify his warning to the public under date of the 6th instant so as not to prejudice consumers against such apple slices that are dried (evaporated) on wooden racks and contain no zinc. This has been done publicly by the mayor as follows:

"My notice of the 6th instant has given rise to the misunderstanding that the eating of American evaporated apple slices are injurious to health, and those persons offering such article for sale would be punished. This is by no means the case. The notice has reference only to such American dried apple slices as have been dried on zinc netting and contain zinc, and not to those that have been dried on wooden racks and contain no zinc."

If the American firms desire to hold on to this already thriving American trade in this market, they are advised to evaporate the apples only on wooden racks and see to it that the apples so prepared are entirely free of zinc, as the mere traces of this ingredient would cause them to be objected to by the health officials. One agent has suggested to me that it would be advisable for the American firms to furnish with each shipment an authenticated certificate that the apples have been analyzed by an expert chemist and are absolutely free from zinc.

ANALYSES UNDERTAKEN BY THE DEPARTMENT.

In view of the information contained above, analyses were ordered, and it was suggested that, in view of the restrictions referred to, an examination be made of the fruits intended for shipment to foreign ports, and, further, that the State Department be requested to ask our consuls in localities where trade in American evaporated apples was restricted or prohibited, to procure samples, especially of those fruits which were condemned for sanitary reasons, and transmit them to this Division for analysis.

In harmony with these recommendations, instructions were given to secure samples of evaporated apples from exporters in New York City and from the manufacturers, and a communication was directed to the Secretary of State soliciting the cooperation of the consular officers, which was cheerfully granted, and resulted in the receipt, in due time, of samples of evaporated American apples from Frankfort, Germany, together with the following reports:

Restrictions Against American Dried Apples in Germany.

[Report by Consul-General Frank H. Mason at Frankfort.]

In response to recent instructions of the Department, requiring the collection and return of samples of dried American apples which have been condemned by the health authorities in this district for their alleged contamination with salts of zinc, I have to submit, with the accompanying samples, the following report, which will explain in some degree the nature and scope of the restrictions which threaten, under existing conditions, to practically exclude from German markets one of the important minor food products of the United States.

On the 14th of May, 1879, there was enacted in Germany a national law for the protection of the people from danger through the sale of adulterated, impure, or unwholesome articles of food, drink, or medicine. For the enforcement of this law there is in each district or municipality a "Gesundheits-Amt," or bureau of sanitary police, which is charged with the inspection of all food materials, drinks, etc., that are offered for sale within its jurisdiction. Under the scrutiny of these officials evaporated apples of American origin have been from time to time during the past two years condemned on the charge of containing a small admixture of malate of zinc, presumably the result of contact, while drying, with trays made of perforated zinc or galvanized-iron wire. Whether this contamination ever reaches such a degree as to render the fruit actually unwholesome is a point concerning which the German chemists, health officials, and importers have not yet been able to agree, and the controversy has now reached an acute and somewhat perplexing stage.

In November, 1892, an official declaration was issued by Dr. Zimmermann, chief health officer, and Dr. Loock, principal of the royal food inspection bureau for the city of Düsseldorf, concerning the presence of zinc in American evaporated apples. (See Exhibit A, page 19.) In his statement Inspector Loock states that he had at various times analyzed samples of American evaporated apples, and had in most cases found them free from any admixture of zinc. Such as had been found contaminated with salts of zinc contained usually from one-hundredth to five-hundredths of 1 per cent of that material, and the highest percentage ever found by him was 0.09 per cent, an amount of zinc which he declares to be wholly insufficient to render apples prejudicial to human health when cooked and eaten in the ordinary manner. In his accompanying certificate Health Officer Zimmermann confirms this statement of the inspector, and asserts that the maximum quantity of malate of zinc that could be consumed by a person at one meal by eating apples containing the highest admixture yet detected would be less than one-fourth of an ordinary dose of acetate of zinc such as is frequently administered in medical practice, and he thereupon declares the dried apples in question to be manifestly devoid of danger to consumers.

ACTION OF THE IMPERIAL GOVERNMENT.

Notwithstanding this and other similar testimony, the agitation against American evaporated apples continued, and on the 16th of April, 1894, a circular letter was issued by the imperial ministry at Berlin, addressed to the governments of the several States, calling their attention to the dangerous character of American dried apples, and recommending special precautions for their inspection. This mandate, an original copy of which is herewith transmitted, is translated as follows:

[Empire of Germany. Circular from the imperial chancellor to the governments of the German States concerning American dried apples. From the 16th April, 1894.]

"It has been observed that various dried apples, especially those of American origin (evaporated apples), which contain a greater or less percentage of zinc, have been offered for sale. This peculiar defect in these goods is ascribed principally to the drying process employed in America, by which the fruit is evaporated, not as with us upon wooden trays, but upon zinc plates and nets of zinc-covered wire. Whether these apples are not purposely powdered with zinc oxid to give them a more attractive appearance, or whether in some cases this impregnation may be due to the fact that the fruit has been grown upon soil containing an admixture of zinc, are questions which are for the present left out of the account. But at all events, there has been found repeatedly in these goods so high a proportion of malate of zinc that in the opinion of competent experts they are undoubtedly prejudicial to human health, especially since it is to be observed that the forms of food prepared from dried apples are often eaten by persons of weak resistance, such as children and convalescents.

"In order to avert this danger the already existing law provides an adequate remedy, since by the provisions of paragraphs 12, 14, and 15 of the food-product law (Nahrungsmittel-Gesetz) of May 14, 1879, repressive measures may be taken when it is established that the apples contain so high an admixture of zinc as to be prejudicial to health. In fact, such measures have been successfully taken under the authority of the above-cited paragraphs—as is shown by the publications of the Imperial bureau of health, page 658, volume of 1890, and page 115, volume of 1893—against sellers of apples containing zinc; at least the goods were seized and confiscated.

"For the protection of the public against sanitary dangers from the food material now under consideration, it is hereby recommended that the officials and sanitary police who are charged with the execution of this law shall pay especial attention to the sale of dried apples; that they take from time to time samples of such as are exposed for sale and submit the same to examination by the inspecting chemists of food materials, and that they institute proceedings against the sellers of unwholesome goods.

"I request that you will bring this matter to the attention of the proper officials, and give such instructions as may be necessary to carry the law into effect. In case that successive or important cases of this nature may be found within your jurisdiction, you are requested to report the facts to this Department in order that if necessary further and more stringent regulations may be provided, perhaps by the entire suppression of the sale of apples containing zinc, under authority of paragraph 5, section 2, of the food-product law.

"By order of the imperial chancellor:

"VON ROTTENBURG."

In compliance with this mandate, instructions were issued by the royal ministries of Prussia, Saxony, Würtemberg, and Bavaria. The edict was officially published in the organ of the imperial health department for July 25, 1894, and since that time all evaporated apples offered for sale in Germany have been subject to the most careful scrutiny.

One of the first cases which came to trial under these regulations was that of two grocers at Halle, named Baarmann and Werther, who were indicted before the royal civil court of that city for having sold American evaporated apples containing 0.096 per cent of malate of zinc. With them were also indicted and tried Nicolaus Haas and Fr. Arnold Ritter, of Hamburg, the importers from whom the condemned goods had been obtained, and who were therefore held as accessory to the crime. After a fair and full trial, in which the chief health officer of Halle and the sworn chemical expert of the court gave elaborate and precise testimony, the accused were all acquitted and the costs of the suit assessed by judgment upon the treasury of the State. The grounds upon which the court gave this judgment were, briefly, that according to the expert evidence adduced, dried fruit containing the alleged proportion of malate of acetate or zinc could not be considered dangerous to human health, since doses of those salts four times greater than the utmost quantity which a person would consume in a day from eating food prepared in the usual way from dried apples are frequently prescribed in medical practice to the same patient during several successive days without danger of any injurious result. In other words, although the apples under consideration might contain, as charged, a small trace of salts of zinc, the admixture was not sufficient to render them unwholesome, and therefore neither the importers nor grocers who offered them for sale were amenable to penalty nor the goods to seizure.

PROCEEDINGS AT FRANKFORT.

In February of the present year a lot of 25 cases of evaporated apples were imported from Rochester, N. Y., by Mr. Erwin Roelker, of this city, and sold to a local grocer named Latscha. The latter, in order to avoid danger of arrest or confiscation of his goods, took the precaution before offering them for sale, to submit a sample for analysis to a private chemist of high authority, who found them to contain 0.018 per cent of malate of zinc. The apples were thereupon returned by Mr. Latscha to the importer, who, not being satisfied with the result, sent a sealed sample from the same box to the same chemist, without stating from what lot the sample had been taken. The analysis of this second sample showed that it contained only 36.6 milligrams per kilometer, or 0.0036 per cent, of zinc, an admixture so minute as to be hardly discernible by the most delicate process.

Mr. Roelker thereupon applied formally by letter to the police authorities of Frankfort to know whether an admixture of 0.018 per cent of salts of zinc—which had been found by the first analysis above described—would be held sufficient to render dried apples unwholesome and subject the goods to seizure or the seller to prosecution. He received in reply an official statement that an admixture of 0.018 per cent of salts of zinc exceeded the limit of safety, and that if fruit containing that percentage were sold by him he would be liable to prosecution. He then appealed to the provincial government of this department in a long letter, citing the above-quoted decisions from Düsseldorf and Halle, protesting that he had imported and sold American evaporated apples in large quantities during the past fifteen years without ever receiving or hearing of a single complaint from any retailer or consumer of such fruit; that no objection had ever been raised against American apples in any European country except Germany, and, after urging that since the recent tariff reductions in the United States such discrimination against a standard American product was at least ill timed, he asked that the prohibition which the Frankfort police authorities had put upon his trade should be overruled and canceled by departmental authority. To this petition, which was sent on the 19th of February last, no answer has yet been received, and Mr. Roelker's imports of evaporated apples have been discontinued.

About the same time—January, 1895—two boxes of similar apples from a lot received by another Frankfort importer from Chicago were sold to a local retailer named Wiegand, who exposed them for sale in his store. A policeman came, purchased a small quantity, and afterwards returned with a warrant summoning Wiegand to appear for trial at a specified date for violation of the law. Such of the apples as remained unsold were sealed up by order of the court and their further sale forbidden. The trial has been postponed and fixed for four successive dates, the last of which is the 31st of this month. So far as can be ascertained, these repeated postponements have been due to the inability of the court to reconcile or decide between the conflicting analyses of the chemists who have tested the fruit and the diverse opinions of medical experts as to where the danger line in zinc adulteration should be drawn.

The wholly different analyses which may be honestly derived from samples taken from one box of apples, or even from different portions of the same sample, are readily explained by the fact that any sample of say half a pound may contain pieces which have rested upon the tray while drying, while the overlying pieces, not having touched the metallic bottom of the tray, are wholly free from any trace of zinc. But as the presence of one or more contaminated pieces in a box may be sufficient under the present German system to condemn an entire box or shipment, it follows that the future dried apple export trade to this country will depend upon such merchandise being made absolutely free from any trace of zinc.

Meanwhile, earnest protests have been submitted, November 30, 1894, by the chamber of commerce at Hamburg to the committee of the Reichstag on commerce and navigation, and by the chamber of commerce at Bremen to the sanitary bureau in that city, both disclaiming against the present methods of surveillance, declaring the alleged danger from American dried apples to be imaginary, and protesting against a system which if continued will practically exclude from Germany an article of trade which other nations accept without question.

Nine leading firms at Berlin, Breslau, Strasburg, and Frankfort have signed a circular letter declaring that they have each during the past fifteen years sold annually from 500 to 1,000 boxes of American evaporated apples, and that so far as is known to them not a single case of illness has ever occurred from their consumption by persons of all ages and physical conditions. It is further urged by those who protest against the present system that if dried apple imports are to be controlled at all, the inspection should take place at the frontier, and exclude all that are found to be impure, whereas they are now allowed to be entered and are condemned and confiscated only after they have paid duty as imports.

The general situation may therefore be summarized as follows: The importation of American dried fruits to Germany on a large scale began about fifteen years ago, and now amounts to about a million and a half pounds per annum, of which perhaps one-third are evaporated apples.

Against sun-dried fruits of all kinds, no objection whatever is known to exist, but as the record shows, artificially evaporated apples, when dried in zinc or galvanized wire trays, may develop from contact sufficient salts of zinc to be detected when imported to this country. The obvious remedy would seem to be to eliminate zinc entirely from the construction of every apparatus used to dry fruit for export. Wood has been used for this purpose, but it is open to two serious objections: the trays are liable to take fire when exposed to high temperatures, and contact with wood while drying discolors apples and impairs their market value. It is therefore suggested, as an easy way out of the difficulty, that fruit for the German market shall be either sun-dried or evaporated in trays of perforated tin or tinned-wire gauze, either of which, although more expensive than zinc, would soon repay the additional cost by wholly eliminating the present difficulty.

The sun-dried apricots, pears, peaches, and prunes of California and Oregon are recognized as superior to any others of whatever origin, and the two first named are rapidly taking possession of the German market. The import duty on such fruits from the United States is 95 cents per 100 kilograms (220.46 pounds), and they are retailed here at about 22 cents per pound (or half kilogram). It is somewhat remarkable that the best California dried fruits come from Chicago, where exporters take the trouble to send expert agents to the Pacific Coast during the gathering season, where they select and superintend the packing of the fruit.

Of fruits, as well as all other food products, only the best and purest should be exported to a country like Germany, where the laws protecting the public health are so searching and so rigidly enforced that the slightest defect is sure to be detected, and where the whole agricultural population is interested in opposing the importation of foreign products which compete directly with the home-grown supply.

FRANKFORT, *May 22, 1895.*

EXHIBIT A.

[Translation.]

Expert opinion concerning the harmlessness of American evaporated apples, given by the royal chief health officer, Privy Sanitary Counsellor Dr. Zimmermann, and Dr. Loock, chief inspector of the public food-inspection bureau for the city of Düsseldorf.

OFFICIAL ATTESTATION.

At the request of the merchant C. L. Fusbahn, of this city, and as an inclosure with the expert opinion of the municipal and court chemist, Dr. Loock, of this city, herewith presented, I hereby declare that through the eating of a large portion of apple sauce made of the dried apples in question, the amount of malate of zinc which would thereby be consumed by one person would not exceed one-fifth part of a normal dose of that salt which may be prescribed for small children without causing vomiting; and further, that from 0.5 to 1.2 grams of the acetate of zinc, which of all zinc derivates is the most analogous to malate of zinc, are necessary to produce vomiting when administered to small children. In cases of adults, four times the same quantity would scarcely suffice to produce nausea or vomiting.

I therefore consider the eating of American dried apples as manifestly devoid of danger.

DR. ZIMMERMANN,
Chief Health Officer, Privy Counsellor.

DÜSSELDORF, *November 30, 1892.*

Certificate of Food Inspector Dr. Loock.

The city food-inspection bureau of the city of Düsseldorf has been charged from time to time with numerous chemical examinations of American dried apples, from official boards, business firms, etc. These analyses, which in general have tested the quality and quantity of salts of zinc contained therein, have shown the most various results, according to which the wholesomeness of the product is to be judged. A large part of these samples of apples have been found free from zinc. Of those which contained zinc, the greater portion show an admixture of from 0.01 to 0.05 per cent of zinc; the largest percentage found here has been 0.09 per cent.

Considering that evaporated apples are for the most part used as a material for compot (apple sauce), and that in the preparation of such material 100 grams of apples absorb about the same amount of water, and that since not more than 200 grams of compot, containing 100 grams of apples, are consumed by one person at a meal, it follows that through the consumption of that quantity not more than 0.09 gram of zinc salt would be introduced into the human organism, a quantity which, in view of the fact that such apples are not eaten regularly every day, would be quite insufficient to endanger human health.

Dr. Loock,
Chief of the City Bureau of Inspection, Düsseldorf.

Düsseldorf, *November 28, 1892.*

COLLECTION OF SAMPLES AT NEW YORK FACTORIES.

In view of the magnitude of the interests involved, further instructions were given in the autumn of 1895 to investigate the methods employed at some of the principal factories in northwestern New York devoted to the preparation of evaporated apples for the foreign market. The methods of manufacture which were observed in these factories have already been described. In addition to this a large number of samples of evaporated apples was secured. These samples were taken in person with the purpose of securing in a manner as representative as possible the different grades of the prepared fruit under conditions which would, after proper chemical analysis, determine definitely the occurrence of zinc in the products of manufacture and the conditions in which it occurred in maximum or minimum amounts. The samples secured will be sufficiently described in a tabular form hereafter.

During the course of this inspection buyers and shippers of evaporated fruits were interviewed and requested to give their experiences in seeking to sell the merchandise in foreign ports. Without exception, all exporters or dealers with exporters reported great difficulties experienced in certain German markets, and all were anxious for some method to be adopted whereby the objections to American evaporated apples might be removed and the markets of all Europe opened to them without sanitary restrictions.

VIEWS OF DEALERS IN EVAPORATED FRUITS.

In general, the views entertained by dealers and exporters are clearly set forth in the following extracts from correspondence:

From Messrs. Müller & Fuckel, Hamburg, November 26, 1895:

We are under the impression that our authorities are at present using great leniency in the administration of the law which authorizes them to forbid the sale of evaporated apples contaminated with zinc. We, at least, do not remember that any lots here, during this year, have been confiscated for this reason. The contamination in all cases, as far as we know, was only a small one.

We have pleasure to send you by same mail two samples of evaporated apples which, according to an official analysis made here, are reported to contain 0.009 per cent and 0.004 per cent of zinc, respectively.

From Messrs. Pincoffs, Pieters & Co., Chicago, Ill., November 30, 1895:

We have no sample on hand at present of any apples of ours which have been found to contain zinc in Europe, but experience has taught us that careful and close chemical analysis will show some zinc in almost all evaporated apples, except those which are dried on wooden or canvas trays. We have given the matter a great deal of consideration, and naturally it has been of great importance to our business, and the trouble regarding this question which has arisen in Germany during the last few years has done a very great amount of harm to our business, as well as that of our fellow-exporters. It is a positive fact that the percentage of zinc in the evaporated apples is extremely small, and not enough to be of any harm to health, and this is in fact generally admitted by the medical authorities in Europe, but as the law in Germany does not define any percentage of zinc, it is no matter whether practically the article is not dangerous to health; as long as any percentage, however small, is found, the goods can be condemned according to their law.

We believe it is undoubted that a certain element of protection to home industries enters into this outcry against the American evaporated apples, but as no especial discrimination is made against the product of this country, and the law applies to all evaporated apples, whether of home or foreign make, we fear that it will be impossible for our Government to make any representation that could alter the decision of the German authorities. Our Mr. Pincoffs when abroad last year had occasion to investigate this matter fully, and also talked it over with our ambassador in Berlin. We are now exporting a good many apples which we guarantee to be entirely free from zinc, according to German analysis; and if evaporators will dry their apples on trays entirely free from any zinc, and be careful to have no zinc instruments of any kind connected with their evaporating establishments, this guarantee can be made with safety, and we believe it will be of great value if you will point out these facts in your forthcoming bulletin, a copy of which we would be very happy to receive.

From Messrs. Michael Doyle & Co., Rochester, N. Y., November 29, 1895:

We have had considerable trouble and annoyance for the past ten years by reason of the condemnation and rejection of evaporated apples which were reported to contain zinc oxids. The trouble at the present time is principally in the German Empire. It is due entirely to the efforts of local fruit growers to stimulate and encourage the evaporating apple industry in Germany, which has proven a failure there whenever attempted, for the reason that the apples are in too scanty supply, the prices too high, and the people without the technical knowledge necessary to make a good marketable quality at values which will compete with the product of our country. This is the secret of the whole difficulty. Of the thousands of tons used in this country, England, France, and the Scandinavian countries, not a single case of illness has ever been reported from the proper use of the fruit. The action of the German authorities is of about the same nature as that which they are waging against our meat and other products.

We are sorry to advise we have no samples of the goods reported to contain zinc, otherwise would be very glad indeed to send them to you.

From Charles J. Murphy, commissioner for the State of Iowa, U. S. A., London, January 18, 1896:

After considerable inquiry among local fruit dealers, I could find nothing against the evaporated apples (*in re* zinc), and finally called on the great house of Joseph Travers & Sons, whose letter I inclose, which speaks for itself.

From Joseph Travers & Sons, London, E. C., January 17, 1896:

In reference to your question as to the condemnation of American dried apples on account of their being injured by zinc, we have heard of no cases of the kind in England. The complaint originated, so far as we know, in Germany and found its way in the shape of an item of news into some of the English papers. Since your call we have made some inquiries and can hear of no case of the kind in London.

From L. R. Rogers, Albion, N. Y., January 24, 1896:

I am very sorry the analyses were not completed in time to report at Rochester the 22d instant.

Mr. Metcalf, of the firm of Metcalf & Ferguson, of Pittsburg, met me in Rochester with samples of aluminium wire cloth as a substitute for the present galvanized wire cloth so generally in use. I introduced Mr. Metcalf to a number of persons engaged in the evaporating business, who looked the samples over. All seemed interested in finding a substitute for the galvanized cloth. The objection to the samples seemed to be that they would not hold their position—that is, the wire would be moved to one side or out of position in scraping the fruit from the tray, thus ruining the tray very quickly. The galvanizing on the other style cloth holds the wire firmly in place; in fact, same is rigid.

Mr. Metcalf did not have samples of the perforated plates, but from the description of them think they will be just the article we want. He is to send me some samples of same in a few days, and later will send me some plates to be used in an experiment to be made to test them in actual work by the side of the aluminium wire cloth tray—and checked by the galvanized wire tray—in general use. I hope to be then able to find a substitute for the old method; also one that will work perfectly. After making the above experiments, I will report to you fully.

I am very sorry I can not make the experiments now, but the expense would be too great, and to be of any use they should be conducted for two or three days at least as varying atmospheric conditions might require. It is now so late in the season that apples do not handle as earlier in the season; that is, more solid and less juice. I therefore think the tests will be obliged to wait until early fall.

I was told in Rochester last night by the party who sold me the galvanized wire cloth I use on all my trays that same was free from zinc or any trace of zinc, as the firm who made same used tin instead. Therefore I could fully guarantee my evaporated apples free from zinc.

I await your answer with much interest.

From Messrs. E. Myers & Co., New York, February 3, 1896:

In accordance with your request to keep you posted on any developments which might come up in the matter of zinc found or claimed to be found in American evaporated apples in Germany, we herewith beg to hand you a translation of an article contained in the issue of the Leipziger Zeitung, January 16, 1896, on this subject. The original article in German is in our possession and of course is at the service of the Government if they consider it worth while to have it.

You will perceive that their own medical colleges recognize the absolutely harmless character of the worst specimens of American apples found to contain any zinc, even if consumed by the smallest of children. Under this statement of facts it should seem possible for our Government to bring about an amelioration of the police regulations which permit the prohibition of sale of this article of food when it contains the slightest trace of zinc, although recognized to be absolutely harmless to health.

Our trade has suffered most materially from this law, as has that of all other exporters of these goods, and we are all hoping for speedy relief through the action of our Government.

[Translation.]

The secretary of the interior of the Kingdom of Saxony has received notice from the department of the interior of the German Empire that frequently dried apples, especially of American origin, are offered for sale which contain more or less zinc.

It is recommended, in order to protect the people against such danger, that special attention should be given to this article, and that from time to time samples should be analyzed, and, if necessary, sellers should be prosecuted.

In accordance with these suggestions the board of health of Dresden was ordered to take samples from various places where such apples were sold, to determine the quantity of zinc contained therein, and to report thereon.

By this report it was shown that in 7 of the 30 samples analyzed no zinc or only traces could be found, while the remaining 23 contained more or less zinc. In 14 of them the quantity of zinc oxid found in 100 grams of apples varied between 0.001 and 0.008 gram, which is equal to 0.002 to 0.021 gram malate of zinc. In the remaining 9 samples the quantity of zinc oxid found was larger, varying between 0.011 and 0.045 gram in 100 grams of apples=0.023 to 0.110 gram of malate of zinc. Taking into account that the minimum dose of zinc oxid for children is 0.05 gram three times a day, it can not be supposed that children should eat for any length of time three times a day 50 grams of apples. The board doubts if even the three samples with the highest percentage of zinc oxid (0.03 to 0.04 gram in 100 grams) could be called dangerous to health.

As it seems, however, that the department of the interior shares the opinion of some physicians, that apples with a percentage of 0.02 zinc could do harm to health if such apples should be taken in considerable quantities, the board has handed a copy of its report to the municipal board of the city of Dresden, stating the above-named facts.

METHODS OF ANALYSIS.

In the method of analysis employed by Professor Cornwall, the evaporated apples are extracted or digested with very dilute hydrochloric acid for several days. The liquid contents of the mass are separated by filtration, the filtrate concentrated to a small bulk, rendered strongly ammoniacal, and the zinc finally precipitated electrolytically as metal on platinum. In carrying out this process the presence of other metals capable of being electrolytically precipitated upon platinum must be excluded. Cornwall states that he found neither copper nor lead in any of the samples examined by him, but in a few cases iron was present, and the amount of it, as determined in the usual way, was deducted from the total weight of the metal weighed as zinc. In experiments made where known quantities of zinc were added to apples free of that metal, Cornwall found that 98 per cent of the added metal could be recovered by the process employed by him. He therefore regards it as meeting the requirements of accuracy in every respect. The chief objection to the process is found in the long time required in the preliminary digestion of the sample with hydrochloric acid. Cornwall further discovered that there was no connection between the zinc found and the color of the evaporated fruits.

HEFELMANN'S METHOD OF DETECTING ZINC IN EVAPORTED APPLES.

Hefelmann uses the following method for detecting zinc in evaporated fruits (Chemiker-Zeitung, vol. 18, p. 44):

Two hundred grams of the evaporated fruit are placed in a wide-neck flask and covered with enough 25 per cent hydrochloric acid to fully immerse all and allowed to stand, with frequent shaking, for three hours, at a temperature of from 40° to 60°. From two to three times as much water is added as the volume of the hydrochloric acid employed, and the flask is then placed aside, with frequent shaking, in a warm place for twenty-four hours. The contents of the flask are then filtered with the help of a suction pump, washed with 1 per cent hydrochloric acid and finally with boiling water. The extract is concentrated to about one-third of its volume and oxidized for half a day with small quantities of potassium chlorate. The free chlorin is driven off and the mass again filtered, the filtrate supersaturated with ammonia and treated with ammonium sulphide. After twelve hours the precipitate is separated by filtration and oxidized with aqua regia, heated until the chlorin odor has disappeared, strongly supersaturated with ammonia, acetic acid added, and the zinc sulphide precipitated with hydrogen sulphide. After the precipitation is complete, 10 grams of ammonium nitrate are added for each 100 cubic centimeters of the liquid in order to secure a better separation of the zinc sulphide, which, after standing for twenty-four hours, is separated by filtration and washed with water containing hydrogen sulphide and ammonium nitrate. It is then ignited and weighed as zinc oxid, the precipitate being washed with concentrated ammonium nitrate solution before ignition.

Hefelmann expresses the erroneous opinion that the white or yellow-white color and moist condition of American evaporated apples is due to their treatment with a zinc salt for bleaching purposes.

NIEDERSTADT'S METHOD OF DETERMINING ZINC.

At a meeting of the pharmaceutical section of the German Association for the Advancement of Science, at Lübeck, in September, 1895, Dr. Niederstadt, of Hamburg, read a paper on zinciferous apples. (Chemiker-Zeitung, vol. 19, p. 1757.)

Niederstadt uses the following method for the quantitive determination of zinc in evaporated fruits:

Forty grams of the finely cut apples are ignited in a platinum dish until the carbonized mass can be easily powdered in a mortar. This carbonized material is then extracted with hydrochloric acid, the extract separated by filtration and oxidized with potassium chlorate. Afterwards hydrogen sulphide is introduced to test for lead and copper, which if found are separated by filtration. The filtrate is again oxidized with potassium chlorate and the zinc and iron precipitated with ammonium sulphide, the precipitate separated by filtration, dissolved in hydrochloric acid, again oxidized with potassium chlorate, neutralized with sodium carbonate, acidified with acetic and the iron precipitated with sodium acetate and separated by filtration. In the filtrate the zinc is precipitated with hydrogen sulphide, separated by filtration, the zinc sulphide dissolved in hydrochloric acid, precipitated by sodium carbonate, and ignited. In this way 3 milligrams of zinc oxid which were added to apples free of zinc were recovered without loss.

LEGLER'S IMPROVED PROCESS.

Legler has improved the process described in the following way (Chemiker-Zeitung, vol. 19, p. 1763):

Fifty grams of the sample are thoroughly dried in a porcelain dish and with the flame of a gas lamp burned from above until thoroughly carbonized, so that the carbonaceous mass can be easily rubbed to a fine powder, an operation which can be conducted in the dish in which the drying takes place. The finely divided carbon is then extracted with hydrochloric acid at a boiling temperature in covered beakers, the solution diluted, filtered, and washed. To the filtrate an excess of ammonia is added and it is brought to a given volume. In an aliquot part of the filtrate, after the addition of acetic acid in slight excess, the zinc is precipitated with hydrogen sulphide and the excess of this gas removed by boiling. The zinc sulphide is then separated by filtration, dissolved and freed from iron, and finally ignited and weighed in the manner given above. In 100 grams of substance Legler found the following quantities of zinc: In three samples, from 40 to 60 milligrams of zinc; in one sample, from 20 to 30 milligrams; in six samples, from 10 to 20 milligrams; in fourteen samples, from 5 to 10 milligrams; in eleven samples, from 1 to 5 milligrams; in four samples, 1 milligram; in sixteen samples, none.

A comparison of the carbonizing method above described with the oxidation method, depending upon the use of potassium chlorate, showed that the two gave practically identical results. The great simplicity of the carbonizing method gives it, therefore, a decided advantage over the older method. At the temperature required for the carbonization there is no danger whatever of loss of zinc by volatilization.

FILSINGER'S METHOD.

According to Filsinger (Chemiker-Zeitung, 1894, vol. 18, p. 1239)—

It is not absolutely necessary to destroy the organic matter entirely before extracting the zinc, but under certain circumstances the hydrochloric acid extract of the organic matter can be used directly. In this case the hydrochloric acid is neutralized with soda lye, acetic acid added, and the solution treated directly with hydrogen sulphide. The precipitation of the zinc in this case is somewhat hindered by the organic materials which have entered into solution, but the precipitation will take place completely, especially if the solution when saturated with hydrogen sulphide be allowed to stand for some time. A quicker and safer method, however, consists in completely destroying the organic matter of the sample, say 50 grams, by treatment with hydrochloric acid and potassium chlorate.

METHODS OF ANALYSES EMPLOYED IN THE LABORATORY OF THE DIVISION OF CHEMISTRY.

After a careful consideration of the different methods of analyses proposed, the method about to be described was adopted by the Division of Chemistry for the work of analysis of the samples collected. The analytical work for the determination of zinc was carried out by Mr. K. P. McElroy and for moisture and ash by Mr. Oma Carr.

Place the weighed portion of dried apples in a roomy platinum dish and heat cautiously over a low bunsen flame till the mass is thoroughly dry and ignition sets in. The flame is then removed and combustion allowed to proceed spontaneously. Should the burning cease it is to be reinstituted with the aid of the lamp. As a rule, however, the apples will burn of themselves. When the mass is all converted into ash and char, it is to be ground up in a porcelain mortar and extracted with hydrochloric or nitric acid. In the samples done in this laboratory hydrochloric acid was used. The residual charcoal is burnt to a white ash in the same platinum dish, the ash taken up in hydrochloric acid and the solution added to that first obtained. This solution is then filtered. To the filtrate bromine water is added to oxidize the iron, and the excess of bromine removed. A drop of methyl orange solution is placed in the solution and ammonia added till the reaction is only faintly though distinctly acid. Without regarding the precipitate produced, add 50 cc of a solution of ammonium acetate containing 250 grams of the commercial salt (Hess's method). The temperature is then carried to 70° or 80° and the liquid filtered into a liter flask. It is then washed with water of the same temperature till free of chlorids, though so much washing is hardly necessary in view of the limited amount of zinc oxid likely to be present. The filtrate is treated with hydrogen sulphid till saturated, allowed to stand till the zinc sulphid settles, and then filtered through an ashless filter. The filter is washed with a saturated solution of hydrogen sulphid containing a little acetic acid. Frequently, owing to the well-known peculiarities of zinc sulphid, it becomes necessary to return the filtrate several times.

The washed precipitate and containing filter are burnt in a porcelain or platinum crucible, highly ignited and weighed as zinc oxid. Results are good, though sometimes a little high, owing to coprecipitated iron phosphate. In a portion of 200 grams of fresh apples, to which was added a solution of zinc nitrate corresponding to 9.7 milligrams of oxid, 9.8 milligrams were recovered in one case, 10.3 in another. In another portion, to which 19.4 milligrams were added, 18.9 milligrams were recovered. Check samples of the same apples gave no zinc.

In the case of the samples analyzed, from 150 to 450 grams, depending on the size of the sample, were taken for each sample, burnt, and treated as described above, and dissolved. The resulting solution was made up to 300 cc, and duplicate portions of 50 cc each taken for analysis. In nearly all cases 450 grams were employed, and the 50 cc portions therefore represented 75 grams.

DESCRIPTION OF EVAPORATED APPLES AND OTHER ARTICLES ANALYZED.

No. 14075. From Seggermann Bros., 165 Duane street, New York; sample of parcel packed by dealer in Wayne County, N. Y., who buys from small manufacturers and makes one bulk of different lots received from different people.

No. 14076. From firm mentioned above; sample of apples dried on wire trays in one factory in Wayne County, N. Y.

No. 14077. From firm mentioned above; sample of apples dried on wire trays in an evaporator in Oswego County, N. Y.

No. 14078. From firm mentioned above; sample of apples dried on wire trays in a factory in Michigan.

No. 14079. From firm mentioned above; sample of apples dried on wooden trays in Wayne County, N. Y.

No. 14081. From E. Meyers, 436 Produce Exchange, New York; sample of evaporated apples dried on wire trays.

No. 14082. From firm last mentioned; sample of evaporated apples said to have been dried on wooden trays.

No. 14123. Received from Department of State; from United States consul-general at Frankfort on the Main, described in dispatch of Consul-General Mason of May, 1895, marked sample No. 1.

No. 14124. Same as above, marked sample No. 2.

No. 14150. Sample of dried apples described in letter of Frank H. Mason, consul general at Frankfort on the Main, dated June 22, 1895; this sample bears the seal and certificate of the police court before which the trial took place. See letter of consul-general of date mentioned, already given.

No. 14315*a*. From Müller & Fuckel, Hamburg, Germany; according to an official German analysis, this sample is said to contain 0.009 per cent of zinc.

No. 14315*b*. From firm last mentioned; according to the official analysis, this sample is said to contain 0.004 per cent of zinc.

No. 14405. From factory at Walworth, N. Y.; sample taken by H. W. Wiley at the factory from a package put up for shipment.

No. 14409. From factory at Albion, N. Y.; sample taken by H. W. Wiley, October 30, 1895, from two car loads of evaporated apples prepared for shipment to Germany.

No. 14410. From factory mentioned above; sample taken as described above from a large pile of evaporated apples on floor ready for packing.

No. 14411. From factory mentioned above; taken as described from slices which fell off the tray after drying, without shaking, and thus not in contact, or only partially in contact, with the wire netting of the tray; tray had been in use for two years.

No. 14412. From factory last mentioned, being the slices that stuck to the wire cloth of the tray; same tray as above described. These pieces were therefore in intimate contact with the galvanized iron wires.

No. 14413. From factory last mentioned; slices of evaporated apples dried on trays new at the beginning of the season, September 25, 1895. Only those slices were taken that stuck to the trays, the loose ones having been shaken off.

No. 14414. From factory last mentioned; samples of evaporated apples dried on trays which had been in use more than five years. Only those chips were taken that stuck to the wire cloth.

No. 14415. From factory, Walworth, N. Y.; sample taken by H. W. Wiley, October 31, 1895; samples of evaporated apples dried on trays in use two years; these trays were greased about every third day with tallow to prevent the slices from sticking. The whole sample was taken, no attempt being made to get only those which were nearest the wire.

No. 14416. From factory last mentioned; sample taken as noted; sample of evaporated apples, including the skins and cores; manufactured expressly for the French trade, and to be used in making jellies, marmalades, and in flavoring wines.

No. 14417. From C. H. Perkins, Newark, N. Y.; sample of evaporated apples such as are placed on the general market; no data obtainable in regard to where or how the evaporation took place, except that it represented the product of western New York.

No. 14418. Sample of apples purchased from F. M. Walker & Co., 938 Louisiana avenue SW., Washington, D. C. These apples were cored, pared, bleached, and sliced in the laboratory and were dried on trays made of pure aluminium wire.

No. 14418*a*. Two hundred grams of the fresh apples represented by No. 14418, evaporated and afterwards, to the evaporated fruit, 9.7 milligrams of zinc oxid in solution of dilute nitric acid added.

No. 14418*b*. A duplicate sample of 14418 treated as above.

No. 14418*c*. A sample of 200 grams of the fresh apples represented by 14418, evaporated and treated with 19.4 milligrams of zinc oxid in solution.

No. 14418*d*. Two hundred grams of fresh apples evaporated without addition of zinc.

Nos. 14418 *a*, *b*, *c*, and *d* were all evaporated on platinum.

Table showing per cents of moisture, ash, and zinc oxid in evaporated apples.

Serial number.	Moisture.	Ash.	Ash in dry substance.	Zinc oxid.	Zinc oxid in water-free substance.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
14075	15.41	1.077	1.27	0.0060	.0071
14076	15.14	.919	1.07	0170	.0200
14077	15.41	1.075	1.27	.0078	.0092
14078	30.02	.578	.83	.0082	.0117
14079	18.40	.788	.97	.0021	.0026
14081	21.22	1.583	2.01	.0100	.0127
14082	31.23	.826	1.20	None.	None.
14123	18.26	1.201	1.47	None.	None.
14124	18.98	.971	1.20	.0109	.0123
14150	16.00	.522	.62	.0013	.0016
14315*a*	18.55	.782	.96	.0072	.0088
14315*b*	18.43	.982	1.21	.0112	.0137
14405	22.25	.826	1.06	.0096	.0124
14409	32.59	.851	1.26	.0216	.0320
14410	32.87	.809	1.21	.0148	.0220
14411	32.52	.913	1.35	.0066	.0098
14412	32.47	1.031	1.53	.0148	.0219
14413	33.06	.800	1.19	.0214	.0320
14414	30.58	.793	1.14	.0242	.0348
14415	27.08	.950	1.30	.0056	.0077
14416	23.11	1.022	1.33	Trace.	Trace.
14417	21.26	1.188	1.51	Trace.	Trace.
14418	....	....	....	None.	None.
Means ..	23.85	.931	1.22	.0111*	.0152*
Maxima.	33.06	1.583	2.01	.0242*	.0348*
Minima .	15.14	.522	.62	.0013*	.0016*

* Exclusive of numbers 14082, 14123, 14416, 14417, and 14418.

In order to determine the number of milligrams of zinc oxid in 100 grams of the evaporated fruit, move the decimal points in the zinc oxid column in the above table three places to the right.

DISCUSSION OF DATA OBTAINED.

No. 14075. In this sample is found a fair illustration of what may be expected in a promiscuous lot of evaporated fruits purchased in a locality where drying on galvanized iron wire trays is commonly practiced. The amount of zinc oxid found in this sample, it is true, is extremely small, and expressed as per cent becomes almost a vanishing quantity. Yet the analysis shows a weighable quantity of zinc in 100 grams. The amount ordinarily consumed by any one person in an ordinary meal would probably not exceed 100 grams, so that at the most not more than 10 milligrams of zinc would be introduced into his system, a quantity entirely too small to produce any harmful result. In giving the quantity of zinc found hereunder it is understood that it refers to the amount in 100 grams of the evaporated fruit.

In the next sample, No. 14076, is found a distinct increase in the quantity of zinc, and the fruit in question was known to have been dried on galvanized iron trays and not to have been mixed with other samples before the part for analysis was secured. The quantity of zinc found is nearly three times as great as in the first sample.

In the next sample, No. 14077, is found another instance of fruit known to have been dried on galvanized iron wire trays. A comparison between the two samples indicates how wide the variations may be under conditions which seem to be identical. The explanation of this is found in the fact that in a sample taken promiscuously it is possible at one time to secure a large number of slices which have been in intimate contact with the galvanized wire, and at another a majority of the slices may represent those which were not, or only in partial contact, with the wire.

In sample 14078 a small quantity of zinc is found, and the comment made on the preceding sample is equally applicable to this one.

In sample 14079 a trace of zinc was found amounting, in fact, to 2.1 milligrams. This sample was certified as having been dried on wooden trays. It was secured from a very large dealer, and it is entirely possible that a few slices of evaporated apples dried on galvanized iron may have found a place in it. A sample containing, however, so small a quantity of zinc as indicated could not possibly be condemned on any sanitary grounds, unless, indeed, the presence of even a trace of zinc in evaporated apples should be considered a sufficient reason for prohibiting their sale altogether. It must be remembered, also, that in quantities so small as those mentioned some allowance must be made for the ordinary errors in analysis, and unless a residue, which, for the quantity mentioned gives distinct qualitive reactions for zinc, is obtained the chemist can not positively testify to its occurrence.

In sample 14081, obtained from the same firm as the preceding, and purchased as having been dried on galvanized iron wire trays, a small quantity, amounting to 10 milligrams of zinc oxid, was found. No special comment is indicated on this sample.

In sample 14082, which was said to have been dried on wooden trays, not even a trace of zinc was found.

Sample 14123 is a sample of evaporated apples transmitted by Consul-General Mason, of Frankfort, accompanied by a dispatch to the State Department dated May 22, 1895. The sample is described in Mr. Mason's dispatch as one which had been condemned by the police authorities of

Frankfort on account of its alleged contamination with salts of zinc. Our analysis revealed the fact that this sample was entirely free of even a trace of zinc, and its condemnation therefore by the police authorities of Frankfort is completely unjustifiable.

In sample 14124, derived from the source mentioned above and marked sample No. 2, a small quantity of zinc was found, amounting to 10 milligrams of zinc oxid in 100 grams of the sample.

The sample 14150 was an officially sealed sample of evaporated apples taken from a lot, imported by Erwin Roelker, of Frankfort, from Albert Petrie, of Rochester, N. Y. As a result of an analysis made by the health authorities of Frankfort it was certified that the sample contained from 0.0035 to 0.9545 gram of zinc or salts of zinc per kilogram, a proportion which was adjudged prejudicial to human health. The sample bore the seal and certificate of the police court before which the dealer in these apples was tried. It was transmitted through the State Department by Consul-General Frank H. Mason, Frankfort on the Main, under date of June 22, 1895. This sample was found to contain but little more than a trace of zinc, viz, 1.3 milligrams in 100 grams, which is a little more than the minimum quantity certified to in the police records. It is difficult to understand why a sample which contained but little more than a mere trace of zinc could have been condemned for sanitary reasons.

Sample No. 14315*a* was sent by request of this Division by Müller & Fuckel, of Hamburg. According to an official analysis made in Hamburg for the health office this sample was said to contain 9 milligrams of zinc per 100 grams, or 0.009 per cent, which corresponds to a little over 11 milligrams of zinc oxid per 100 grams, a quantity which seems to be about the normal for the ordinary samples dried on galvanized iron wire.

Sample 14315*b* was received from the firm last mentioned, and, according to the official analysis, it was said to contain 0.004 per cent of zinc, which corresponds to 0.005 per cent of zinc oxid. In our analyses of these two samples the respective quantities of zinc contained therein were found to be 7.2 and 11.2 milligrams, respectively, for 100 grams. The two samples came without any distinctive marks, so that we were unable to determine the order in which they should come, except by the results of the analysis. It is evident, therefore, that the sample which we have marked *a* corresponds with the one containing, by the German analysis, 0.004 per cent of zinc, and the one marked *b* to the sample containing, by the German analysis, 0.009 per cent of zinc.

Sample 14405 was secured at a factory in Walworth, N. Y. A package which had been prepared for shipment was opened, its contents thoroughly mixed, and the sample for analysis taken. The fruit was dried on galvanized iron wire trays. It was found to contain the usual quantity of zinc oxid characteristic of fruit prepared in this way.

Sample 14409 was secured at a factory in Albion, N. Y. A car which had been loaded for shipment was opened and a box of fruit taken at random, and the sample prepared from this box. The fruit was dried on galvanized iron wire. The quantity of zinc which we found in this sample was about double that usually found, and apparently by accident there was secured a large quantity of slices which had been in contact with the galvanized iron.

Sample 14410 was taken at the same place as the preceding from a large pile of fruit ready for packing. The analysis shows that it contains the usual quantity of zinc oxid. This fruit was dried on galvanized iron wire.

In securing the next sample, No. 14411, from the same factory as that above, an attempt was made to get as many as possible of the slices which had only been in partial contact with the wire. For this purpose a tray taken directly from the kiln was turned upside down and the slices which fell off without shaking were secured for analysis. As was to have been expected, the results of the analysis indicate a considerable diminution of the content of zinc, which was found to be only 6.6 milligrams of zinc oxid for 100 grams.

The next sample, No. 14412, consists of the slices which remained attached to the zinc when the tray was turned upside down, as indicated above. The quantity of zinc in this sample, viz, 21.4 milligrams of zinc oxid, is more than three times as great as that found in the preceding sample.

Sample 14414 consists of slices of evaporated apples which remained attached to the galvanized iron wires when a tray taken from the kiln was turned upside down. The tray on which the apples were dried had been in use more than five years. The sample contained 24.2 milligrams of zinc oxid per 100 grams. In comparing this with the preceding sample, which was dried on trays in use the first year, it is seen that the continued use of the tray does not tend to diminish the danger of contamination with zinc.

Sample 14415 was secured from another factory in Walworth, N. Y. The sample was dried on galvanized iron wire trays which had been in use for two years. The proprietor of the factory is in the habit of greasing his trays with tallow about every three days to prevent the slices from sticking thereto. The utility of this method is indicated in the low content of zinc found, viz, 5.6 milligrams for 100 grams of fruit.

Sample 14416, from the manufacturer mentioned above, represents the whole apple, including the cores and skins. The trays on which these apples were dried were also well greased, and only a trace of zinc was found in the sample.

In sample 14417 is seen an illustration of the character of the fruit which may be bought in the general market. The history of this sample could not be traced, but from the fact that it contained only a trace of zinc it is fair to presume that it was either dried on wooden trays or on galvanized iron trays which were kept well greased.

Sample 14418 represents a laboratory product prepared from apples purchased in the open market in Washington. These apples were put through as nearly as possible the process employed in the manufacture on a large scale, with the exception that they were dried on a tray made of pure aluminium wire. The analysis, as was to be expected, disclosed not even a trace of zinc.

EXAMINATION OF THE GALVANIZED IRON WIRE USED FOR MAKING THE TRAYS.

It was thought to be a matter of interest to examine the galvanized iron wire cloth used for making the trays employed in the manufacture of evaporated apples. For this purpose samples were secured at the factory of L. R. Rogers, Albion, N. Y., representing the unused material and also that which had been constantly employed in the factory for over five years. It would follow as a natural result from the use of this material that the zinc covering of the wire would gradually be dissolved by the acids of the apples and that in the end the iron core would be practically denuded. In practice, however, it is found that the constant rubbing of the trays to detach slices of evaporated apples wears them out before the zinc is entirely removed. The results of the analytical data which follow show, however, that a large percentage of the zinc originally enveloping the iron core is dissolved in the course of a few years. When the small quantity of zinc in a tray is taken into consideration, it seems unreasonable to suppose that any marked contamination of the product could ensue. Many thousand pounds of fruit are evaporated on a single tray before it becomes unfit for use. From the data which follow, however, it is seen that a tray having a surface of one square yard carries about 2 pounds of zinc. This would be sufficient to contaminate 20,000 pounds of evaporated apples with the average quantity of zinc oxid found therein in our analysis, viz, 10 milligrams per 100 grams. The analytical data of the examination of the wire cloth obtained by Mr. K. P. McElroy, follow:

EXAMINATION OF WIRE CLOTH.

No. 14406. Unused wire cloth, from L. R. Rogers:

Weight of 1 square yard of this cloth is 5.03 pounds. It is composed of 59.77 per cent iron and 40.23 per cent of zinc. On this basis 1 square yard would contain 2.02 pounds of zinc.

No. 14407. Unused wire cloth (one year old), from L. R. Rogers:

On handling this cloth particles of zinc scaled off freely. The weight of 1 square yard is 3.08 pounds. It is composed of 60.65 per cent iron and 39.35 per cent zinc. One square yard therefore contains 1.21 pounds of zinc.

No. 14408 A. Wire cloth in use more than five years, from L. R. Rogers:

Water extracts from this cloth traces of a soluble zinc salt, probably malate, and a little iron. The weight of a square yard of this cloth is 2.38 pounds. It is composed of 80.68 per cent iron and 19.32 per cent zinc. One square yard contains 0.46 pound of zinc.

No. 14408 B. Wire cloth in use more than five years, from L. R. Rogers:

Sample a part of the same lot as above. Water extracts a soluble zinc salt. The metal is composed of 84.77 per cent iron and 15.23 per cent zinc. One square yard weighs 2.18 pounds and contains 0.33 pound of zinc.

It is seen that there is a gradual disappearance of the zinc with use, the quantity in one tray dropping from about 2 pounds to one-third of a pound in five years.

PHYSIOLOGICAL ACTION OF ZINC.

It is probable that the zinc salts contained in evaporated apples exist entirely in the form of organic salts, the most abundant of which is zinc malate. The physiological effects of the organic salts of zinc have not been comprehensively studied, the only one used in medicine being the valerianate. The valerianate of zinc has antispasmodic properties and has also been used as a remedy in neuralgic affections. In general, however, the physiological effects of the zinc salts, as found in evaporated apples, may be assumed to be similar to those of the inorganic salts of zinc. The sulphate of zinc is the salt which is most generally used for medicinal purposes. It is tonic and astringent and in large doses produces prompt emesis.

There are a few cases on record of fatal poisoning from large doses of the salt. In one of the fatal cases an ounce and a half of the zinc sulphate was swallowed by mistake for epsom salts. A like quantity of the salt taken at the same time by another patient produced severe toxic symptoms, but did not result fatally. In many cases large doses of the salt have been administered for many days without any symptoms of toxic effects. In one instance 36 grains of salt were given three times a day for six weeks without the appearance of any symptoms of poisoning. All writers on toxicology, however, agree that in certain quantities zinc salts exercise a poisonous effect. While the continued administration of zinc salts in small quantities has not been known to produce any very decided disturbance of the physiological functions of the body, yet the continued administration of this substance even in minute doses can not be recommended. All authorities agree that even if zinc be regarded as poisonous it is decidedly less so than lead and copper. A case is recorded (in the Chemisches Central-Blatt, fourth series, Vol. I, 1894, p. 642) in which from 50 to 100 milligrams were administered every day for from two to six months without any disturbance in the health of the animals experimented on. Zinc does not accumulate in the system except in small quantities in the bones.

Zinc salts have also a certain antiseptic value and have been used to a slight extent for that purpose. They are also used to a very limited extent for fixing the chlorophyll colors of preserved vegetables, especially with pease and beans.

ZINC AS A NATURAL CONTENT OF APPLES.

There is one point of interest to analysts which should not be overlooked, viz, the possibility of zinc occurring naturally in plants. Researches of the past few years have shown naturally present in plants many metals which a few years ago were supposed never to enter the plant organism. It is possible that fruit trees growing in localities where zinc abounds may take this metal into their organs and fruits, as is the case with copper and other rare metals sometimes found as natural products in plants. It would be of interest to have fruits which grow in localities where the soil is known to contain zinc examined for this substance. If it should be found that plants have the power of absorbing zinc, the presence of a mere trace of this substance in evaporated apples would no longer be conclusive evidence of their having been dried on galvanized iron wires. According to Filsinger (Chemiker-Zeitung, 1894, vol. 18, p. 1239) there is already sufficient evidence on record of the ability of plants to absorb zinc to render permissible the question as to whether traces of zinc found in American evaporated apples might not arise from the soil on which the orchards stand.

SUBSTITUTION OF OTHER MATERIAL FOR GALVANIZED IRON WIRE IN THE MANUFACTURE OF TRAYS.

The results of the investigations which have been conducted show that as long as galvanized iron wire trays are used for evaporating apples it is not possible to guarantee that the product shall be free of zinc. The difficulty of securing even drying on wooden slats and the fragility of trays made of cloth are sufficient reasons for excluding these two materials from consideration in the manufacture of drying trays. The fact that aluminium is now manufactured at a very cheap rate suggested the possibility of using this material in making trays. With this purpose in view, inquiries were directed to the Pittsburg Reduction Company in regard to the matter. This company showed a lively interest in the question and kindly made, for the use of this Division, 12 square feet of aluminium wire netting suited to the purpose required. This wire at the present time costs 90 cents a pound, which would indicate that the cost of the aluminium in a square yard would be a little over 60 cents. If there were much demand it could probably be made for very much less. There would probably be one practical difficulty in the use of the aluminium wire netting, arising from the fact that the strands not being soldered together might be displaced by the wooden paddle which is used in scraping the dried apples from the tray. The spaces in the netting would thus become unequal and possibly in some cases large enough to allow the slices to fall through. It has been suggested to use perforated sheet aluminium for the bottoms of the trays. If this could be done it would remove the difficulty mentioned above.

Only experience will show how long the aluminium wire would withstand the action of the acids of the fruit. It is not probable, however, that it would be dissolved at any greater rate than the zinc of the galvanized iron. The small quantity of alumina which would be introduced into the fruit could not possibly be regarded as objectionable.

It would be useful also to substitute iron wires covered with tin for the galvanized iron at present in use. Wire netting could be prepared and covered with tin at a much less expense than aluminium could now be furnished. The coating of tin, evidently, for such a purpose should be much heavier than that for ordinary tinware, so that the iron may be in all points deeply covered, and thus avoid the galvanic action which would ensue on the portion of iron exposed. The tin employed should be pure, and especially free of lead. Pure tin is much more resistant to the action of acids than zinc, and the amount of tin which would be found in evaporated fruits dried on tin trays would probably be infinitesimal.

While it is true that it would cost the manufacturers a considerable sum to throw away the trays which they now have and substitute for them those which would cost a great deal more money, yet the expense seems to be worth incurring. To be able to absolutely guarantee the product free of zinc would result in opening a wide and profitable market to our evaporated fruits, and in the removal of any justifiable hygienic reasons for restricting their sale.

SUMMARY.

(1) In many European markets the consumption of American evaporated apples is either restricted or prohibited by alleged hygienic reasons resting upon the supposed contamination of the product with zinc.

(2) In several cases where samples of condemned products have been secured through the agency of our consuls and others, an analysis has disclosed the presence of zinc in some of them and proved its absence in others. In the latter case the prohibition of the sale of the product was evidently discriminating and unjust.

(3) In samples of American evaporated apples secured from large dealers and directly from the factories, weighable quantities of zinc have been found in nearly every instance in which the drying was accomplished on galvanized iron wire trays.

(4) The results of the analyses have shown that the slices which were dried in intimate contact with the galvanized iron wire contained a far larger content of zinc than those in which the contact was less intimate.

(5) An analysis of the galvanized iron wire cloth composing the bottoms of trays shows that in each square yard of the new cloth about 2 pounds of the zinc are present, and that when these trays have been in use for several seasons the total quantity of zinc is very much diminished, but that still considerable quantities are present when the trays are too much worn for further use.

(6) It has been seen that the age of the tray does not greatly affect the quantity of zinc which is contained in evaporated apples.

(7) Experiments have shown that pure aluminium wire may be used for making the netting on which the apples are dried, and it is probable that perforated sheet aluminium may also be found useful for this purpose. By the use of pure aluminium the presence of zinc could be entirely excluded from the evaporated fruits, and thus all hygienic objections to their use would fall. The presence of the minute amount of alumina which would be introduced into the evaporated fruit would be of no consequence, inasmuch as alumina is a natural constituent of nearly all food products. Well-tinned iron wire would also make an acceptable substitute for the wire covered with zinc now in use.

(8) The manufacturers of evaporated apples in this country should at once rigidly exclude all galvanized iron utensils from their factories and substitute therefor drying trays composed of aluminium, tin, or some other substance which will not permit of any objectionable ingredient entering the finished product. The use of bronze cutting instruments should also be excluded and steel substituted.

(9) The physiological effects of the organic salts of zinc are not well understood. The inorganic salts of zinc taken in large quantities act as irritant poisons. Small quantities of zinc salts are constantly administered in the practice of medicine, producing tonic and astringent effects. The continued use of small quantities of zinc for a long period of time has not been known to produce any serious results. Experience has shown that zinc is distinctly less poisonous than copper or lead.

(10) The normal quantity of zinc in the form of oxid found in American evaporated apples which have been dried on galvanized iron trays is about 10 milligrams for every 100 grams of the fruit, or a little less than 50 milligrams per pound. One grain, druggists' weight, is equivalent to 65 milligrams. The quantity of zinc, therefore, in 1 pound of evaporated apples dried on galvanized iron trays is only about two-thirds of a grain. The quantity of zinc which would be taken by any one person in an ordinary meal at which dried apples were served would probably in no case ever exceed two-fifths of a grain. It is not possible to regard this quantity as in any way prejudicial to health.

(11) The continued use of bodies which are not distinctly poisonous, but which are foreign to the natural constituents of the system, may finally produce derangement of health, and for this reason the manufacturers of evaporated fruits in this country should pursue such processes as would exclude even the traces of zinc above mentioned.

(12) American dried apples contain nearly one quarter of their weight as water and ash, the mean percentage of water in the samples examined being nearly 24 and of ash nearly 1.25. The extreme variations in moisture from the mean were found to be about 8 per cent.

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DIVISION OF CHEMISTRY.

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PROCEEDINGS OF THE THIRTEENTH ANNUAL CONVENTION OF THE ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS.

FIRST DAY.

FRIDAY—MORNING SESSION.

Pursuant to a call issued by the executive committee, the Association of Official Agricultural Chemists met at 10.30 a. m., Friday, November 6, in the lecture room of the National Museum.

The president, Mr. B. B. Ross, called the convention to order and nominated the following committee on order of business, viz: L. L. Van Slyke, G. L. Teller, and H. J. Patterson. The committee, after consultation, reported the following order of business:

First. President's address.

Second. Report on methods of determining nitrogen, and reading of papers relating thereto.

Third. Report on methods of analyzing potash, and reading of papers relating thereto.

Fourth. Report on methods of soil analysis, and reading of papers relating thereto.

Fifth. Report on methods for the analysis of phosphoric acid, and reading of papers relating thereto.

Sixth. Report on methods of analyzing foods and feeding stuffs, and reading of papers relating thereto.

Seventh. Report on methods of analyzing carbohydrates; papers and discussion.

Eighth. Report on methods of analyzing fermented and distilled liquors; papers and discussion.

Ninth. Report on methods of analyzing tanning materials; papers and discussion.

The election of officers for the ensuing year was fixed as a special order for Saturday afternoon, November 7, at 3 o'clock.

The president read the annual address to the association, which follows.

ADDRESS OF THE PRESIDENT.

GENTLEMEN OF THE ASSOCIATION: Our organization assembles to-day in its thirteenth annual convention after the lapse of a longer period than has intervened heretofore between any two consecutive meetings. The date selected for this meeting by vote of the executive committee was determined upon in order to enable chemists connected with the work of experiment stations and agricultural colleges to attend the meetings of this association and also the sessions of the convention of agricultural investigators and educators which assembles in this city on the 10th instant, and I trust that we have present among us some members who have been unable heretofore to attend regularly the meetings of this body.

The long interim between the last convention and the present has no doubt afforded to the reporters, and those taking part in the work of cooperative and individual investigation, additional opportunities for practical tests and studies of our methods of analysis, and I trust that the reports and results presented for our consideration will make easy the task of passing upon the questions awaiting the action of this convention.

The work of our association has become so comprehensive in its scope and so diversified in its character that it is impossible in the short time at my disposal to touch even in a cursory manner upon the varied subjects and questions to be considered by this body.

The various departments and divisions of the work coming within the province of the association is, moreover, so well covered by committees and reporters that it would be an act of supererogation on my part to enter into the detailed consideration of any individual topic or question which might demand our attention, nor will I anticipate the presentation of the work of the reporters by offering in advance any extended remarks upon questions which they are better prepared to discuss.

The foreign literature relating to the subject of fertilizer analysis, while somewhat abundant during the past year, presents, as far as my observation extends, little that is new, and the bulk of this literature is devoted to the consideration of only a few features of the subject.

The methods for the determination of phosphoric acid and potash have received, so it would appear, no little attention at the hands of foreign investigators, and yet a large proportion of the articles relating to the former substance treats of the analysis of Thomas slag and particularly of the citrate solubility of that material.

In the foreign literature, with reference to phosphoric acid determinations, we find quite a voluminous contribution by Meineke,[1] which treats of the results of a number of comparative tests of the leading methods in use and gives especial attention to a comparison of the processes of Wagner and Maercker as relates to the precipitation with magnesia mixture, while Foerster has presented quite a lengthy dissertation on the relation between the citrate solubility and soil solubility of phosphoric acid with especial reference to Thomas slag.

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[1] Chem. Ztg., 20, 108.

The Wagner citrate method, as it appears in the official methods of the German Manure Manufacturers' Association and as published in the Chemiker Zeitung (No. 63, 1895), appears to be meeting with quite extensive employment at present, and it is claimed that the analytical tests give results corresponding quite well with the actual soil availability.

The subject of the determination of the approximate availability of phosphoric acid in certain forms of nonacidulated phosphates has often been discussed by this association, and it has been frequently stated that our present citrate method fails to give altogether satisfactory results upon certain classes of raw phosphates.

A sample of Florida soft phosphate recently examined in the Alabama State Laboratory gave 0.78 per cent citrate soluble phosphoric acid by our association method, 0.31 per cent by Wagner's citrate method as applied to Thomas slag, and 0.84 per cent by Wagner's method as employed for precipitated phosphates and superphosphates.

These meager results would seem to indicate that the methods of Wagner have little advantage over our present method so far as phosphates of this character are concerned, and the details of the process for Thomas slag are more troublesome than the official method.

Of course, in matters involving modification of existing methods or the adoption of any supplementary methods, the association, as has been its wont, will proceed with great caution, and a thorough practical study of the subject would be necessary in advance of the adoption of any modifications of, or additions to, our present methods, even if the association should see fit to make any alterations.

The question of taking steps in the direction of securing greater harmony and a closer agreement between the official methods in use in this country and in the principal European countries received the favorable consideration of this association some three years since, and cooperation with foreign chemists has been obtained to a limited extent at least, during the period referred to, a number of samples each year having been placed in the hands of European analysts for comparative tests.

On the 27th of July the World's Congress of Applied Chemistry assembled in Paris in its second biennial session, and since one of the leading objects of this congress was to promote a closer agreement between, and a nearer approach to, uniformity in the analytical methods employed in the leading industries in the various countries represented, a statement as to the outcome of this convention would be of great interest.

The distinguished secretary of this association was in attendance upon the congress referred to, and has already presented in a recent number of the Journal of the American Chemical Society an extremely interesting account of its proceedings and deliberations. I trust, however, that the association will be favored with a further statement as to the results of the congress and as to the prospects of harmonizing the methods of analysis at present employed in the principal countries of the world.

As stated in the above article of Dr. Wiley, and as reported in the résumé of the proceedings published in the Bulletin de L'Association des Chimistes de Sucrerie et de Distillerie, it was directed by vote of the congress that the official methods of Germany, France, and the United States be published in both the French and German languages, the work of editing and publication being placed in the hands of D. Sidersky, of Paris, the author of the well-known treatise on sugar chemistry.

The above journal also states that a commission, consisting of representatives of three different sections of the congress, was appointed to formulate or prepare methods for the determination of potash in the principal technical or commercial products containing this constituent.

The members of our association have no doubt been pleased to learn of the action taken with reference to the publication of our official methods in both French and German, as our methods have in the past been ignored to a great extent by chemists on the other side of the water. In a number of instances, methods adopted by our association or reported in our proceedings have appeared, after the lapse of some time, in foreign periodicals, possibly with some of the minor details modified slightly, if at all, and without any statement or acknowledgment as to the origin of the method thus reproduced. With our methods, however, published under the sanction of this congress of chemists in the two chief languages of Continental Europe, let us hope that transatlantic chemists will become better acquainted with our processes of analysis and will concede to them at least a share of the merit and recognition which is accorded them at home.

A recent report of a committee, appointed by the Belgian Association of Chemists to investigate the comparative merits of the leading methods for potash determination in use in the laboratories of that country, gives the results of tests of a number of processes, although the Lindo-Gladding method does not appear in the list of methods investigated. The results reported seem to indicate that there is quite a diversity in the methods employed in that country, and also that the same method in the hands of different analysts fails to give satisfactory and concordant results. The sample of fertilizer sent out for these cooperative tests had a known content of 5.40 per cent of water soluble potash, while the results reported by eight chemists vary from 4.69 to 6.51 per cent, a variation between the extremes of 1.82 per cent, amounting to about 33.5 per cent of the actual potash content, or about 39 per cent of the minimum result.

We should take courage from the examination of these figures, which read somewhat like some of the association's past results for crude fiber or nitrogen free extract, and our organization is to be congratulated that, so far as our fertilizer work is concerned, the variations in results of our cooperative tests of samples have been reduced within limits much narrower than we had originally hoped to attain at so early a period of the association's existence.

A recent number of the Bulletin de l'Association des Chimistes makes mention of a new nitrogenous fertilizer calcium cyanate, which awaits employment at the hands of European agriculturists, but little information is given with regard to its probable economic value or utility.

The fertilizer control in some of our Southern States has experienced some little trouble during the past year or two on account of the sale or offering for sale of formulæ or receipes for the preparation of home-mixed manures designed to supplant or supersede the commercial article. In practically all such cases the formulæ are absolutely worthless, as they prescribe the use of such substances as ammonium nitrate, commercial ammonia, caustic potash, soda ash, bluestone, sulphur, free phosphoric acid, and various inert bodies or incompatibles which are mixed together and incorporated with some such material as ordinary earth or barnyard scrapings. In several of the States the sale of such fraudulent formulæ has been promptly exposed and the attention of the agricultural public called to the worthlessness of such recipes.

In accordance with a resolution of this association adopted at a former meeting, the work of the abstract committee has appeared in regular installments with each issue of the Experiment Station Record, and we are thus enabled to secure the benefits of foreign contributions to the literature of agricultural analysis, presented in a convenient and condensed form, and reaching us much more promptly than by the publication of such abstract matter in the same volume with our annual proceedings.

At the last annual meeting of this association the president in his opening address called attention to the importance of the study and investigation of foods for human consumption, and pursuant to a resolution adopted at that time a committee was appointed to consider what attitude it is desirable for this body to assume with reference to food adulterations and legislation relating thereto, and a report from this committee will no doubt be presented in due order.

Our methods for the analysis of dairy products, as they stand at present, are of course chiefly quantitative in their character, and although extremely comprehensive, do not include tests for the more common adulterants or preservatives encountered in such materials. It is true that methods covering these cases are within easy reach of every chemist who has access to reference works and periodical literature on the subject, but in cases of this character, which frequently come before the courts for adjudication, the findings of the chemist will be largely strengthened if it is known that the methods employed in his tests have received the official sanction of an association of this character.

The investigations of the Division of Chemistry of the United States Department of Agriculture, continued through a number of years, have, however, supplied ample contributions to every department of the literature of foods and food adulterations, and a reference to its publications on this subject will supply the desired information in almost every individual case which may arise.

The Division of Nutrition Investigations has given much time and attention to the study of the composition of the chief food materials consumed in the various sections of this country, and has conducted a large number of dietary studies in the Northern, Western, and Southern States, the results of these investigations being embodied in a series of publications issued by the Department.

The matter of the analysis of foods and feed stuffs, as shown by the experience of this association, is one of the most difficult questions connected with the work of this organization, but with the progress already made in this line of work, and in view of the success already attained in other departments of association work, we have reason to hope for substantial improvement in the near future.

In the meantime, while the processes employed are doubtless the best within our reach at present, it is nevertheless to be conceded that, as regards some constituents, the methods provisionally in use constitute simply a modus vivendi until something better is secured.

In the consideration of the question of changes in our methods of analysis, the association will no doubt continue to pursue the policy it has adhered to in the past, and while we have not hesitated to alter or discard existing methods when it is shown by actual results and figures that another process is more desirable, our proceedings have, at the same time, been characterized by a spirit of conservatism which "makes us rather bear those ills we have than fly to others that we know not of."

MEMBERS AND VISITORS PRESENT.

The following members and visitors were present:

Allen, W. M., Raleigh, N. C.
Allen, E. W., Office of Experiment Stations, United States Department of Agriculture, Washington, D. C.
Armsby, H. P., Director Agricultural Experiment Station, State College, Pa.
Bigelow, W. D., Division of Chemistry, United States Department of Agriculture, Washington, D. C.
Battle, H. B., North Carolina Experiment Station, Raleigh, N. C.
Beal, W. H., Office of Experiment Stations, United States Department of Agriculture, Washington, D. C.
Buckley, S. S., Maryland Agricultural College, College Park, Md.
Bomberger, F. B., Maryland Agricultural College, College Park, Md.
Curtis, H. E., Lexington, Ky.
Carr, Oma, Corry, Pa.
Carpenter, F. B., Virginia-Carolina Chemical Company, Richmond, Va.

Cutter, W. P., Librarian, United States Department of Agriculture, Washington, D. C.
Caldwell, G. C., Cornell Experiment Station, Ithaca, N. Y.
Crampton, C. A., Treasury Department, Washington, D. C.
Clarke, F. W., Chief Chemist United States Geological Survey, Washington, D. C.
Davidson, R. J., Virginia Agricultural Experiment Station, Blacksburg, Va.
Dugan, J. A., Division of Chemistry, United States Department of Agriculture, Washington, D. C.
Ewell, E. E., Division of Chemistry, United States Department of Agriculture, Washington, D. C.
Frear, William, Agricultural Experiment Station, State College, Pa.
Fraps, G. S., Johns Hopkins University, Baltimore, Md.
Goss, Arthur, Mesilla Park, N. Mex.
Gaines, R. H., State Chemist of Virginia, Richmond, Va.
Herff, B. von, 99 Nassau street, New York, N. Y.
Hills, J. L., Vermont Agricultural Experiment Station, Burlington, Vt.
Hite, B. H., Morgantown, W. Va.
Hird, J. D., Chemist District Board of Health, Washington, D. C.
Huston, H. A., State Chemist of Indiana, Lafayette, Ind.
Johnson, S. W., Yale University, New Haven, Conn.
Kilgore, B. W., Raleigh, N. C.
Langworthy, C. F., Office of Experiment Stations, United States Department of Agriculture, Washington, D. C.
Laughlin, J. R., Maryland Agricultural College, College Park, Md.
Lindsey, J. B., Hatch Experiment Station, Amherst, Mass.
McDonnell, H. B., State Chemist, College Park, Md.
Merrill, L. H., Orono, Me.
Moore, C. C., Division of Chemistry, United States Department of Agriculture, Washington, D. C.
Myers, J. A., Director Agricultural Experiment Station, Morgantown, W. Va.
Patrick, G. E., Division of Chemistry, United States Department of Agriculture, Washington, D. C.
Patterson, H. J., Agricultural Experiment Station, College Park, Md.
Peacock, S., American Fertilizer Co., Philadelphia, Pa.
Penny, C. L., Newark, Del.
Perkins, W. R., Agricultural College, Mississipi.
Quick, W. J., Columbia, Mo.
Ross, B. B., Alabama Experiment Station, Auburn, Ala.
Runyan, E. G., Division of Chemistry, United States Department of Agriculture, Washington, D. C.
Street, J. P., Agricultural Experiment Station, New Brunswick, N. J.
Schweinitz, E. A. de, Bureau of Animal Industry, United States Department of Agriculture, Washington, D. C.
Scovell, M. A., Kentucky Experiment Station, Lexington, Ky.
Shutt, F. T., Ottawa, Canada.
Skinner, W., Maryland Agricultural College, College Park, Md.
Teller, G. L., Agricultural Experiment Station, Fayetteville, Ark.
Trescot, T. C., Division of Chemistry, United States Department of Agriculture, Washington, D. C.
Van Slyke, L. L., Agricultural Experiment Station, Geneva, N. Y.
Veitch, J. P., Maryland Agricultural College, College Park, Md.
Wheeler, H. J., Chemist Rhode Island Experiment Station, Kingston, R. I.
Wiley, Harvey W., Chief of Division of Chemistry, United States Department of Agriculture, Washington, D. C.
Williams, C. B., Johns Hopkins University, Baltimore, Md.
Winton, A. L., New Haven, Conn.
Yocum, J. H., 30 Ferry street, New York, N. Y.

The **President.** Before proceeding to the regular order it will be necessary to appoint a committee on recommendations of reporters. The committee will consist of Messrs. Wheeler, Huston, Van Slyke, Gaines, and Kilgore.

Following the regular order, the reporter on nitrogen now has the floor.

Mr. Street. I beg to present the following report:

REPORT ON NITROGEN.

By John P. Street.

The work of your reporter this year was largely influenced by suggestions made at our last convention. The Ulsch and zinc-iron methods for nitric nitrogen and the Fassbender method for total nitrogen were recommended for further trial. In addition to these lines of work it has seemed to me to be advisable to give some attention to the question of the availability of organic nitrogen, so that, even if no conclusive results were secured, this important question might at least be started toward a satisfactory solution. The report will therefore be considered under two heads:

I. New methods of determining nitrogen in commercial fertilizers.

II. A preliminary study of the availability of organic nitrogen.

Early in December a letter requesting cooperation was addressed to 60 chemists, representing all of the American experiment stations and several commercial firms. Twenty-four favorable replies were received to this letter, and of this number 16 have reported results either on all the work or in part. On July 30 a letter of instruction was sent to those who had signified a wish to take part in the work.

PREPARATION OF SAMPLES.

Three samples of fertilizers were prepared for distribution. The materials used in compounding these mixtures were sodium nitrate, potassium nitrate, tankage, cotton-seed meal, linseed meal, ammonium sulphate, acid phosphate, potassium chlorid, and sodium chlorid. These ingredients were dried for five hours at from 60° to 70° C., and were then allowed to stand exposed to the air for fifteen hours in order that they might become in equilibrium with the atmosphere. They were then ground to pass through a one twenty-fifth inch sieve and bottled. The salts were afterwards passed through a one-fiftieth inch sieve also. After grinding they were thoroughly mixed and samples for analysis taken, the results of which follow:

Nitrogen as—	Nitrates.	Ammonia.	Organic N.	Total N.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Sodium nitrate	15.89			15.89
Potassium nitrate	13.20			13.20
Tankage		0.20	12.06	12.26
Cotton-seed meal			7.69	7.69
Linseed meal			6.03	6.03
Ammonium sulphate		21.18		21.18
Acid phosphate			.13	.13

No traces of nitrogen were found in the potassium chlorid or sodium chlorid.

The ingredients of the different mixtures were then spread out on a heavy paper and thoroughly mixed, from one to two hours, by turning with a spatula and passing through a drug mill. They were then bottled and sealed, and the first, tenth, twentieth, and thirtieth bottles of each series were kept for the use of the reporter.

The mixtures were made up as follows:

Sample No. 1:
900 grams sodium nitrate, containing 143.01 grams nitrogen.
525 grams potassium nitrate, containing 69.30 grams nitrogen.
75 grams potassium chlorid.
Or 14.15 per cent nitric nitrogen.
Sample No. 2:
150 grams sodium nitrate, containing 23.83 grams nitrogen.
300 grams cotton-seed meal, containing 23.07 grams nitrogen.
300 grams linseed meal, containing 18.09 grams nitrogen.
600 grams acid phosphate, containing 0.78 grams nitrogen.
150 grams potassium chlorid.
Or 4.38 per cent total nitrogen, containing 1.59 per cent nitric nitrogen.
Sample No. 3:
225 grams sodium nitrate, containing 35.75 grams nitrogen.
75 grams ammonium sulphate, containing 15.89 grams nitrogen.
300 grams tankage, containing 36.78 grams nitrogen.
750 grams acid phosphate, containing 1.08 grams nitrogen.
150 grams potassium chlorid.
Or 5.96 per cent total nitrogen, containing 2.38 per cent as nitrates and 1.10 per cent as ammonia.

In preparing these mixtures, No. 1 was intended to represent a highly nitrated sample and Nos. 2 and 3 commercial fertilizers—one containing nitrates and the other both nitrates and ammonia, in connection with organic nitrogen.

As a check on the thoroughness and evenness of mixing, total nitrogen was made in portions from four different bottles of each sample with the following results:

The following table shows the percentage of total nitrogen in four determinations:

Sample.	A.	B.	C.	D.
No. 1	14.12	14.12	14.12	14.14
No. 2	4.39	4.40	4.41	4.39
No. 3	6.04	6.03	6.06	5.99

From these results it is evident that the samples left the reporter's hands thoroughly homogeneous and well mixed.

ULSCH-STREET METHOD FOR NITRATES.

The method recommended was slightly different from that published in the last report of the association, and is as follows:

Place 1 gram of material into a flat-bottomed 500 cc flask; add 2 to 3 grams of reduced iron, 25 cc of water, and 10 cc of sulphuric acid (sp. gr. 1.35). Shake well wash down the sides of the flask with a little water, and boil gently for five minutes. (Where the material is very rich in nitrates, as in nitrate of soda, the use of a dropping bulb is recommended.) Add about 100 cc of water, a little paraffin, and 3 to 5 grams of heavy oxid of magnesia; distill for thirty-five to forty minutes, nearly to dryness, and titrate as usual. The nitrogen obtained represents the nitrates, plus the ammonia, contained in the sample.

In the analysis of nitrate salts proceed as above, except that 25 cc of the nitrate solution are employed with 5 grams of reduced iron. After boiling add 75 cc of water and an excess of sodium hydrate, and proceed as above.

Cautions.—The magnesium oxid should be fresh and practically free from carbon dioxid. In the distillation bring to a boil very gradually, as at first there is a tendency to foam.

Percentage of nitrogen by Ulsch-Street method by distillation with NaOH and MgO.

Analyst.	No. 1.		No. 2.	No. 3.
	NaOH.	MgO.		NH_3 deducted.
Wisconsin Station, F. W. Woll	13.85	....	1.59	[1]2.67
Virginia Station:				
R. J. Davidson	13.78	....	1.62	2.43
A. T. Eskridge	13.77	....	1.63	2.44
W. B. Ellett	13.66	....	1.63	2.46
Maryland Agricultural College:				
F. P. Veitch	14.09	....	1.67	2.33
H. B. McDonnell	13.90	....	1.68	[1]2.24
F. B. Bomberger	13.86	....	[1]1.72	2.47
Illinois Station, C. G. Hopkins	14.02	13.98	[1]1.70	2.31
Vermont Station, C. H. Jones	....	14.16	1.65	2.31
Pennsylvania Station:				
W. S. Sweetser	13.87	....	1.68	2.35
C. A. Browne	13.77	....	1.66	2.35
United States Department of Agriculture, T. C. Trescot	14.09	....	[1]1.79	2.31
Lister's Agricultural Chemical Works, C. S. Cathcart	14.04	....	1.62	2.36
New Jersey Station, J. P. Street	14.15	....	1.62	2.38
Average	....	....	1.64	2.38
Theory	14.15	....	1.59	2.38

[1] Omitted from the averages.

COMMENTS OF ANALYSTS.

R. J. Davidson: Obtained 14.17, 14.17, and 14.22 in No. 1 by the following modification: To the 25 cc of solution taken, add 100 cc of water, 5 grams of reduced iron, and 15 cc of sulphuric acid (1.35); let stand until all action ceases, then heat for five minutes and add 100 cc of water, a little granulated zinc and paraffin, and 30 cc of sodium hydrate; distill almost to dryness. He experienced considerable difficulty from bumping when sodium hydrate was used.

Maryland Agricultural College: Preparatory to distillation the solutions were heated slowly for forty-five minutes, and then boiled for five minutes with the following results:

Percentage of nitrogen.

Analyst.	No. 1.	No. 2.	No. 3.
F. P. Veitch	14.22	1.67	2.56
H. B. McDonnell	14.17	1.72	2.49
F. B. Bomberger	14.11	1.70	2.37

Fourteen chemists reported results by the modified Ulsch method The results secured in No. 1 are far from satisfactory. Of the 14 sets reported only six approach the calculated percentage. The results vary from 13.66 to 14.15 per cent, or 0.49 per cent. No trouble whatever was experienced in the New Jersey laboratory when the instructions sent out were strictly followed. If the analysts had followed the method strictly, especially the steps after the reduction was effected, it is difficult to understand why good results would not have been secured. Incomplete distillation is probably the chief cause of the low results. A brisk boiling of forty minutes, which is usually nearly to dryness, will cause all the ammonia to be distilled over. Some of the analysts reported difficulty with bumping when the solutions became low. Several hundred determinations by this method have been made in the New Jersey laboratory and we have never experienced this difficulty. The freshness of the magnesium oxid is a very important point. The instructions expressly stated that fresh oxid should be used for the liberation of the ammonia. We have had some trouble with this method occasionally in the past, and have always found the cause to be impurity of the magnesia used. Exposure to the air causes it to carbonate, which not only decreases its effectiveness but renders the titration very difficult as well as inaccurate.

Several suggestions have been made also as to the preliminary treatment of the solution before and during the reduction period. The experience of our laboratory with the method is that the amount of acid used and the time of boiling have little to do with the final results. Whether 5, 10, or 15 cc of sulphuric acid are used, or whether the solution is boiled five minutes or one hour, matters little. The smaller amount of acid has been found, by actual trial, to be quite sufficient, and the larger quantity was recommended for the sole purpose of insuring an excess. As to the time of boiling or digesting, Ulsch, the originator of the method, has shown (Zeit. Anal. Chem., 30, 175–182) that the conversion of the nitrates into ammonia is almost instantaneous, less than one minute being required for the operation. It will be seen, therefore, that an extended boiling of the solution theoretically should have little effect on the results. The concentration of the solution is also important. In all of our work with the Ulsch method, especially on nitrate of soda, we have endeavored to keep the solution as concentrated as possible. Our experience is that the greater the concentration is, the less difficulty there is in securing a complete distillation of the ammonia.

It is to be regretted that the results on this sample are no better. The method has been before the association for nearly five years and has been used for that period by the New Jersey Station, where it has given perfect satisfaction. The results this year would seem to indicate that the analysts have not followed the method exactly as given in all its details, probably omitting some apparently unimportant step, on which however may depend the method's success. It is also instructive to notice that six of the analysts, who reported low results on this sample by the Ulsch method, had quite as much difficulty in securing satisfactory results by the Kjeldahl and Gunning methods, both of which are accepted methods of this association. Their results by these methods varied from 0.28 to 0.71 per cent less than the theoretical composition. One analyst reported a result 0.50 per cent below theory, and while requesting him to repeat his work I asked for a portion of his sample that I might test it also. My three results were 14.13, 14.10, and 14.10 against 14.15 theory. This would seem to offer additional testimony as to the uniformity of the sample sent out.

The results obtained by this method in samples 2 and 3 are all that could be desired. In sample 2 only 3 of the 14 chemists vary from theory by more than 0.10 per cent, while the greatest variation is 0.20 per cent; in sample 3, only 2 of the 14 vary more than 0.09 per cent, one being 0.29 per cent higher than the other 0.14 per cent lower than theory. These results show that in mixed fertilizers at least the modified Ulsch method is an excellent working method, rapid and accurate.

ZINC-IRON METHOD.

The method recommended for trial was that given in Bulletin 46 of the United States Department of Agriculture, page 22.

Percentage of nitrogen.

Analyst.	No. 1.	No. 2.	No. 3.
Virginia Station:			
R. J. Davidson	13.80	1.68	2.30
A. T. Eskridge	13.66	1.68	2.40
W. B. Ellett	13.83	1.62	2.35
Illinois Station, C. G. Hopkins	14.03	1.66	2.38
Vermont Station, C. H. Jones	14.16	1.67	2.30
United States Department of Agriculture, T. C. Trescot	13.53	....	2.30
Averages	13.84	1.66	2.34
Theory	14.15	1.59	2.38

Only six chemists reported results by this method. The work on sample 1 is quite as unsatisfactory, if not more so, than that secured by the Ulsch method on the same sample, only two chemists approaching theory, while there is a variation from 13.53 to 14.16 per cent, or 0.63 per cent. In samples 2 and 3 the results were much better, the variations being slight, and all quite near the average. The reporter has repeatedly tried this method during the past three years and has never been able to secure satisfactory results with it. In samples containing much organic matter there is a very decided tendency to foam, and during the distillation it is almost impossible to prevent the mechanical carrying over of alkali. The results on samples 2 and 3, while good, are by no means conclusive. The source of their organic nitrogen was cotton-seed meal, linseed meal, and tankage, all of which are quite refractory materials. On samples containing dried blood and other materials whose nitrogen is easily decomposed, it would seem that some of the organic nitrogen would pass over in the distillation, thus giving high results. It was this tendency which prompted the reporter to modify the Ulsch method, so that magnesium oxid was used in place of sodium hydrate. The reporter regrets that through inadvertence, in the preparation of his samples, he overlooked this method, so that it will be impossible to deduce from the results secured any definite conclusions.

FASSBENDER METHOD.

The method recommended by the reporter was as follows:

Place 1 gram of material into a Kjeldahl flask, cover with 20 cc of water, shake and allow to stand for ten minutes; then add 2 grams of powdered iron (reduced iron answers very well) and 10 cc of sulphuric acid (sp. gr. 1.35). Warm gently on furnace until evolution of hydrogen ceases. Add 0.7 gram of mercuric oxid and 20 cc of strong sulphuric acid, and proceed as in the Kjeldahl method.

Percentage of nitrogen.

Analyst.	No. 2.	No. 3.
Lister's Agricultural Chemical Works, C. S. Cathcart	4.27	5.96
Virginia Station:		
R. J. Davidson	4.37	[1]5.65
A. T. Eskridge		5.87
W. B. Ellett	4.53	[1]5.65
Maryland Agricultural College:		
F. P. Veitch	4.39	5.99
H. B. McDonnell	4.34	5.93
F. B. Bomberger	4.37	5.91
Illinois Station, C. G. Hopkins	4.44	6.18
North Carolina Station, W. M. Allen	4.31	6.02
Vermont Station, C. H. Jones	[1]3.77	[1]4.41
Pennsylvania Station:		
W. S. Sweetser	4.21	5.75
C. A. Browne	4.21	5.73
New Jersey Station, J. P. Street	4.40	6.01
Connecticut Station, A. L. Winton	[1]4.41	[1]5.95
Averages	4.35	5.94
Theory	4.38	5.96

[1] Not included in the averages.

Thirteen chemists reported results by this method. The results are fairly satisfactory, but not as close as they might be. In sample 2 the results of four analysts vary more than 0.10 per cent from the average, while only one varies more than 0.18 per cent. When it is remembered that a very large proportion of the nitrogen of this sample is derived from cotton-seed and linseed meal, this variation is not so surprising.

In sample 3, omitting the three results varying more than 0.25 per cent from the average, we find seven chemists reporting results less than 0.09 per cent from theory, while three vary from 0.21 to 0.24 per cent. The work by the Fassbender method on these samples is, on the whole, all that could be expected from the first trials of an unfamiliar method. The reporter is satisfied that with it, as with the Ulsch method, when failure to obtain good results occurs, it is usually due to lack of practice in the manipulation of the method.

At the last meeting of the association the nitrogen reporter called attention to a number of comparative results obtained by this method by Mr. L. H. Merrill, of the Maine Station, and by myself. These tests were secured in our regular fertilizer work and, as the results show, were very satisfactory. In 32 samples Mr. Merrill secured an average of 2.39 per cent by the Gunning and 2.37 per cent by the Fassbender method. In 107 samples I obtained an average of 2.96 per cent by the modified Kjeldahl and 2.99 per cent by the Fassbender method. In addition to these results I have made during the past season some additional comparative tests which follow:

Per cent of nitrogen obtained by different methods.

Official.	Fassbender.	Official.	Fassbender.	Official.	Fassbender.	Official.	Fassbender.	Official.	Fassbender.
2.51	2.44	3.15	3.10	1.06	0.98	1.66	1.67	3.51	3.53
2.58	2.51	2.77	2.65	1.93	1.83	2.04	1.97	3.07	3.85
2.50	2.58	3.29	3.28	1.74	1.65	1.36	1.28	1.82	1.74
3.78	3.69	2.04	2.05	2.88	2.78	3.97	4.08	2.25	2.18
3.92	3.92	1.55	1.49	1.69	1.60	2.66	2.65	2.97	2.95
4.33	4.30	3.11	3.12	2.96	2.86	2.42	2.49	4.52	4.53
3.11	3.06	2.45	2.49	2.04	2.06	3.35	3.32	1.57	1.53
3.15	3.07	3.30	3.33	3.60	3.51	2.70	2.63	1.99	2.00
3.34	3.44	2.59	2.49	1.75	1.69	1.83	1.81	1.47	1.37
3.05	2.95	2.91	2.84	3.53	3.43	2.01	1.97	2.47	2.49
3.84	3.82	1.66	1.60	3.18	3.06	3.38	3.41	2.66	2.55

Averages: Official, 2.69; Fassbender, 2.65.

Fifty-five comparative tests were made, by which an average of 2.69 per cent was obtained by the official method and 2.65 per cent by the Fassbender. The samples tested represented regular commercial fertilizers, and the analyses were all made in the rush of routine work.

MISCELLANEOUS RESULTS.

Some of the analysts reported results which did not properly come under the discussion in the preceding sections, and which I tabulate below:

Per cent of nitrogen obtained by different methods.

Analyst.	No. 1.			No. 2.		No. 3.	
	Kjeldahl.	Gunning.	Fassbender.	Kjeldahl.	Gunning.	Kjeldahl.	Gunning.
Lister's Agricultural Chemical Works, C. S. Cathcart	14.02	....	....	4.33	....	5.96	....
Wisconsin Station, F. W. Woll	....	....	....	4.44	....	5.83	....
Virginia Station.							
R. J. Davidson	....	....	....	4.36	4.33	6.02	6.08
A. T. Eskridge	....	....	....	....	4.43	5.97	5.87
W. B. Ellett	....	....	....	....	4.42	....	5.90
Maryland Agricultural College:							
F. P. Veitch	....	13.44	....	....	4.28	....	5.94
H. B. McDonnell	....	....	....	....	4.14	....	5.78
F. B. Bomberger	....	13.74	14.22	....	4.16	....	5.73
Illinois Station, C. G. Hopkins	14.06	....	13.98	4.45	....	6.12	....
North Carolina Station, W. M. Allen	14.07	....	....	4.33	....	6.06	....

Per cent of nitrogen obtained by different methods—Continued.

Analyst.	No. 1.			No. 2.		No. 3.	
	Kjeldahl.	Gunning.	Fassbender.	Kjeldahl.	Gunning.	Kjeldahl.	Gunning.
Rhode Island Station, B. L. Hartwell	....	....	....	4.35	....	6.01	....
Vermont Station, C. H. Jones	....	....	....	4.29	....	5.85	....
Pennsylvania Station:							
W. S. Sweetser	14.05	....	....	4.33	....	5.72	....
C. A. Browne	[1]13.87	....	....	4.31	....	5.77	....
United States Department of Agriculture, T. C. Trescot	....	....	....	....	4.40	5.97	5.98
New Jersey Station, J. P. Street	14.14	....	....	4.39	4.36	6.03	6.04
Averages	14.07	13.59	14.12	4.36	4.32	5.94	5.92
Theory	14.15	....	....	4.38	....	5.96	....
Connecticut Station, A. L. Winton	....	....	....	4.40	4.37	5.94	5.96

[1] Omitted from the average.

The results in No. 1 by the modified Kjeldahl method are very satisfactory, especially when it is remembered that all the nitrogen is in the nitric form. Five of the six results reported vary less than 0.10 per cent from theory.

The results by the Gunning and Fassbender methods are too few to warrant any conclusions, although the Gunning results are somewhat disappointing in light of the fact that the method has already been made official. In Nos. 2 and 3 the results by both the modified Kjeldahl and Gunning methods are very good, with two or three exceptions. In No. 2 the result by the Kjeldahl method varies more than 0.10 per cent from theory, while only two by the Gunning show such a variation. In No. 3 five of the twelve results reported vary more than 0.10 per cent, but only two more than 0.20 per cent from theory. Two of the analysts experienced difficulty with the Gunning method in all three samples, as they did with the Ulsch method also.

MAGNESIUM-OXID METHOD.

Percentage of nitrogen.

Analyst.	No. 3.
Lister's Agricultural Chemical Works, C. S. Cathcart	1.09
Wisconsin Station, F. W. Woll	1.00
Virginia Station:	
R. J. Davidson	1.11
A. T. Eskridge	1.00
W. B. Ellett	1.07
Maryland Agricultural College:	
F. P. Veitch	1.07
H. B. McDonnell	1.07
F. B. Bomberger	1.10
Illinois Station, C. G. Hopkins	1.05
Rhode Island Station, B. L. Hartwell	1.08
Vermont Station, C. H. Jones	1.01
Pennsylvania Station:	
W. S. Sweetser	1.05
C. A. Browne	1.05
United States Department of Agriculture, T. C. Trescot	1.10
New Jersey Station, J. P. Street	1.09
Average	1.06
Theory	1.10

Fifteen analysts determined the nitrogen existing in the form of ammonia in No. 3 by the magnesium-oxid method. No result varies more than 0.10 per cent from theory and only three more than 0.05 per cent.

QUALITATIVE DETERMINATION OF NITRIC NITROGEN.

It is of considerable importance to the farmer that he should know in what form the nitrogen which he buys exists. It is also of importance to this association that the results of its analyses should convey to the farmer just as much definite information as possible. The difference in cost to the manufacturer of the different forms of nitrogenous matter furnishes another argument for this differentiation of the forms of nitrogen. The average wholesale prices per pound of raw materials during 1895 were 11, 13.5 and 11.2 cents per pound for nitric, ammoniacal, and organic nitrogen, respectively. Of the 331 complete fertilizers analyzed in New Jersey this year 187, or 56 per cent, contained nitrogen in the nitric form and 104, or 31 per cent, contained nitrogen derived from ammonia salts. As long as these variations in composition and cost exist it would seem only just, both to the manufacturer and the consumer, that the proper division should be made. While this is done in most of the stations, the practice is by no means universal. In the light of these facts the reporter would recommend the association to provide that in all fertilizer work these three forms of nitrogen should be determined.

Inasmuch as most of the stations do follow this practice, it has seemed to the reporter that the official methods would be more complete were a qualitative method for nitric nitrogen inserted in our report. The following method, based on well-known principles, is therefore recommended:

Five grams of the fertilizer are mixed with 25 cc of hot water and filtered. To a portion of this solution add two volumes of concentrated sulphuric acid, free from nitric acid and oxids of nitrogen, and allow the mixture to cool. Add cautiously a few drops of a concentrated solution of ferrous sulphate, so that the fluids do not mix. If nitrates are present, the junction shows at first a purple, afterwards a brown color, or if present only in a very minute quantity, a reddish color. Another portion of the solution may be taken, and 1 cc of a dilute solution of nitrate of soda (3 grams to 300 cc) be added and tested as before to determine whether sufficient sulphuric acid has been added in the first test.

THE AVAILABILITY OF ORGANIC NITROGEN.

The increase of the fertilizer trade and the consequent seizure of any waste materials available for use in that trade have offered in some cases a temptation to certain manufacturers to make use of raw products, which, while they would show little effect in field practice, would nevertheless obtain a good analysis in the chemical laboratory. This tendency, although it may not be alarming at present, if developed as it may be, and as there are many reasons to believe that it will be, finds us without proper methods for its detection and correction. We have the means to determine how much of the total nitrogen exists as nitrates or ammonia, but the origin of the organic nitrogen is not revealed to us in our ordinary methods of analysis. Our present methods do not attempt to indicate whether the source is blood, tankage, cotton-seed meal, flesh, fish, or bone, all of which are valuable fertilizing materials, or whether it is garbage, tankage, leather, or wool waste, which are comparatively worthless.

This question is not a new one to American chemists, but up to the present time no method has been devised which gives universal satisfaction. While it is admitted that the only true test is one in which the fertilizers are tried on actual crops, and nature allowed to be the interpreter, still such a method is so time consuming as to be impracticable in most of our laboratories. While it is impossible to imitate exactly the action of the soil on a small amount of fertilizing material, the relative solubility of the materials under examination can be determined in the laboratory and compared with their relative crop-producing power. Then, as Dr. Jenkins says, "if these two methods of examination give concordant results, the first named may be adopted as a test of the availability of nitrogen in mixed goods, which from the nature of the case could not be tested by the method of field or pot experiment."

Stutzer and Klinkenberg in 1882 suggested a method where the digestion was effected by a solution of pepsin. Drs. Shepard and Chazal, of South Carolina, applied the method to some peculiarly American ammoniates, and Dr. Jenkins, of Connecticut, has carried the work still further by also testing the method of putrefaction fermentation proposed by Morgen.

The conclusions from the experiments of these investigators are given in the report of the Connecticut Station for 1893, which I quote:

1. The nitrogen of dried blood, cotton seed, castor pomace, and maize refuse was in every case soluble in pepsin-hydrochloric acid, by twenty-four hours' digestion, to the extent of 75 per cent or more.
2. The nitrogen of fish, dried animal matter, and of bone was in every case soluble to the extent of over 52 per cent.
3. The nitrogen of leather, steamed or extracted by benzine, was in no case soluble to the extent of over 36 per cent. That of horn shavings, ground horn and hoof, cave guano, felt waste, and wool waste was considerably less soluble than the nitrogen of leather.
4. This method divides the organic nitrogenous matters used in fertilizers into two classes. In one, more than one-half of the nitrogen is soluble; in the other, scarcely more than one-third is soluble. To the first class belong all the materials whose nitrogen is known to be readily available in the usual sense. Of the second class the most soluble are leathers variously manipulated, which are comparatively worthless as ingredients of commercial fertilizers. To some extent this method is therefore a measure of the agricultural value of nitrogen. How far it is a measure must be determined by vegetation experiments under accurately controlled conditions, in which nitrogen is supplied in the same materials which have been tested by digestion experiments.

In the meantime the method has decided value, because in many cases it will distinguish in mixed fertilizers between such forms of nitrogen as the general sense of practical farmers accepts as available and such as the same tribunal condemns as inert.

After a carefully conducted series of vegetation tests in a large number of nitrogenous materials and tests by the pepsin-hydrochloric acid method in the same, Dr. Jenkins has come to the conclusion that, in general, the solubility of the nitrogen of these samples in pepsin solution was a fairly good measure of the relative availability of the nitrogen to the plant under the conditions of the vegetation experiment. In horn and hoof and dissolved leather, however, the amount of nitrogen dissolved by the pepsin was no indication of its availability.

PEPSIN TESTS IN COMPLETE FERTILIZERS.

In 1893 the Connecticut Station tested every mixed fertilizer analyzed by the station that year with pepsin-hydrochloric acid to determine the solubility of its organic nitrogen in that reagent. One hundred and twenty-five brands were examined with the following result:

In 3 brands over 90 per cent of the nitrogen were soluble in pepsin.
In 22 brands between 80 and 90 per cent of the nitrogen were soluble in pepsin.
In 62 brands between 70 and 80 per cent of the nitrogen were soluble in pepsin.
In 18 brands between 60 and 70 per cent of the nitrogen were soluble in pepsin.
In 12 brands between 50 and 60 per cent of the nitrogen were soluble in pepsin.
In 6 brands between 40 and 50 per cent of the nitrogen were soluble in pepsin.
In 2 brands under 40 per cent of the nitrogen were soluble in pepsin.

A fertilizer showing 60 per cent of its organic nitrogen soluble in pepsin may be considered as above suspicion, and one falling as low as 50 per cent must not necessarily be condemned, while one below 50 per cent must be regarded as suspicious. From the above tabulation it will be seen that in 1893 eight samples, or 6 per cent, of the mixed fertilizers sold in Connecticut fell in the suspicious class.

In order to determine whether the same condition existed in New Jersey, I tested in the same manner 49 brands sold in our State in 1895. I was limited in my tests by lack of time, and while the number of fertilizers tested represents only a small proportion—18 per cent of the total number analyzed during the year—43 manufacturers are represented, and it is believed that the results secured are indicative of the average composition of New Jersey samples.

One gram of the fertilizer was washed on a filter with 250 cc of cold water to remove all soluble salts, and the residue was treated with the pepsin solution as hereinafter described. The results follow:

In 3 brands between 80 and 90 per cent of the nitrogen were soluble in pepsin.
In 13 brands between 70 and 80 per cent of the nitrogen were soluble in pepsin.
In 16 brands between 60 and 70 per cent of the nitrogen were soluble in pepsin.
In 11 brands between 50 and 60 per cent of the nitrogen were soluble in pepsin.
In 4 brands between 40 and 50 per cent of the nitrogen were soluble in pepsin.
In 2 brands under 40 per cent of the nitrogen were soluble in pepsin.

It will be seen from the above that six, or 12 per cent, of the fertilizers examined have such a low availability that they must be regarded with suspicion. The results in Connecticut and New Jersey therefore agree in indicating that there are suspicious mixed fertilizers on the market. Their number, however, is not great, and those in New Jersey, at least, represent, with one exception, the product of small manufacturers whose product does not exceed 50 tons per annum.

Nevertheless the existence of these few suspicious fertilizers led your reporter to prepare some special mixtures and test them still further with pepsin and such other reagents as had been brought to his attention. Five samples were therefore prepared as follows:

Sample 4.—Dried blood, 90 grams; acid phosphate, 290 grams; muriate of potash, 70 grams, containing 2.92 per cent nitrogen, 8.26 per cent available phosphoric acid, and 7.86 per cent potash.

Sample 5.—Tankage, 108 grams; acid phosphate, 272 grams; muriate of potash, 70 grams, containing 3.04 per cent nitrogen, 7.74 per cent available phosphoric acid, and 7.86 per cent potash.

Sample 6.—Hoof meal, 85 grams; acid phosphate, 295 grams; muriate of potash, 70 grams, containing 2.58 per cent nitrogen, 8.40 per cent available phosphoric acid, and 7.86 per cent potash.

Sample 7.—Raw leather, 180 grams; acid phosphate, 200 grams; muriate of potash, 70 grams, containing 2.57 per cent nitrogen, 5.92 per cent available phosphoric acid, and 7.86 per cent potash.

Sample 8.—A suspicious-looking complete fertilizer sold in the State by one of the leading manufacturers. It contained small pieces of material strongly resembling leather in structure and appearance. It contained 2.03 per cent nitrogen, 8.21 per cent available phosphoric acid, and 6.04 per cent potash.

In the preparation of these samples it was intended to keep the relative amounts of the different fertilizing elements in about the same proportion. The nitrogen and potash were practically the same in samples 4, 5, 6, and 7, while the phosphoric acid varied from 5.92 to 8.40 per cent.

Before the samples were sent out Dr. Jenkins very kindly consented to conduct a series of vegetation tests with oats, using the samples I had prepared. These tests were made in pots such as are described in the Connecticut Report for 1893, page 231, and in the same kind of artificial soil as there described. To the artificial soil were added 5 grams of carbonate of lime, but it was believed that each of the fertilizers supplied enough of phosphoric acid and potash for the growth of the crop.

In the following table are given the amounts of nitrogen supplied, the weights of the separate crops, the nitrogen contained in them, and the percentage availability of the organic nitrogen. The table shows only what the crops have taken up and does not include the roots. There remains, of course, a certain amount of nitrogen in the soil in the form of roots, but it has been assumed, from the light of other experiments, that this residue is not large.

Vegetation experiments on oats.

No. of pot.	Nitrogen supplied.		Crop harvested (exclusive of roots).				Nitrogen increase.	Per cent of the fertilizer-nitrogen assimulated.	Average availability of nitrogen.
	In form of—	Quantity of nitrogen supplied.	Weight of air-dry crop.	Weight of water-free crop.	Per cent of nitrogen in air-dry crop.	Total nitrogen of crop.			
		Grams.	*Grams.*	*Grams.*		*Grams.*	*Grams.*		
251	No. 4, dried blood	0.5	70.8	62.16	0.40	0.283	0.224	44.8	46.5
252		.5	83.7	72.98	.36	.301	.242	48.4	
253		1.0	118.4	101.99	.43	.509	.450	45.0	
254		1.0	111.6	95.34	.48	.536	.477	47.7	
255	No. 5, tankage..	.5	78.5	69.10	.35	.275	.216	43.2	44.8
256		.5	93.3	80.91	.33	.308	.249	49.8	
257		1.0	125.7	108.45	.43	.541	.482	48.2	
258		1.0	101.7	88.94	.43	.437	.378	37.8	
259		2.0	141.0	125.36	.77	1.080	1.027	51.3	
260	No. 6, hoof meal.	.5	76.1	66.22	.35	.266	.207	41.4	43.4
261		.5	75.0	66.03	.34	.255	.196	39.2	
262		1.0	117.8	102.18	.44	.518	.459	45.9	
263		1.0	112.7	96.74	.47	.530	.471	47.1	
264		2.0	132.1	117.93	.66	.872	.813	40.6	
265	No. 7, raw leather.	.5	20.8	18.07	.36	.074	.015	3.0	3.4
266		.5	21.7	18.91	.34	.074	.015	3.0	
267		1.0	24.3	21.51	.41	.100	.041	4.1	
268		1.0	26.0	22.54	.36	.094	.035	3.5	
269	No. 8, suspicious fertilizer.	.5	58.2	51.59	.36	.210	.151	30.2	29.8
270		.5	60.1	53.19	.33	.198	.139	27.8	
271		1.0	95.3	82.28	.36	.343	.284	28.4	
272		1.0	96.4	82.90	.40	.386	.327	32.7	
273	No nitrogen added.	....	16.6	14.51	.32	.053	Average, .059	....	....
274		....	18.4	16.00	.34	.063			
275		....	17.2	15.00	.35	.060			
276		....	16.2	14.21	.38	.062			

The average availability of the nitrogen shown in the table indicates that the nitrogen of the blood, tankage, and ground hoof in this experiment had practically the same availability, varying from 43.4 per cent in the case of horn to 46.5 per cent in the case of blood. The nitrogen of the raw leather had an availability of but 3.4 per cent, while the suspicious fertilizer confirms our suspicions with the low availability of 29.8 per cent.

From the following table, which shows the average results obtained by Dr. Jenkins on maize and oats with a number of nitrogenous materials, it will be seen that the new results agree very closely with the averages indicated.

	Per cent of available N reckoned on total N. Average of two years.	Same for new experiment.	Average per cent of three experiments.	Per cent of available N reckoned on available N of $NaNO_3$.
Nitrate of soda	68.4	....	68.4	100
Castor pomace	50.6	....	50.6	74
Cotton-seed meal	49.7	....	49.7	72
Linseed meal	47.1	....	47.1	69
Dried blood	46.5	46.5	46.5	68
Dried fish	45.0	....	45.0	66
Dissolved leather	44.7	....	44.7	64
Ground hoof	42.5	43.4	42.8	63
Tankage	40.5	44.8	42.0	61
Steamed leather	6.5	....	6.5	9
Roasted leather	6.5	....	6.5	9
Raw leather	1.5	3.4	2.0	3

In order to find out what relation the availability secured by chemical methods had to that secured by these vegetation tests, samples of the five mixtures prepared for this work were sent to five chemists, who had had some experience with the methods proposed.

Two methods were proposed for trial—the pepsin-hydrochloric acid method and the Hayes potassium permanganate method.

PEPSIN-HYDROCHLORIC ACID METHOD.

The method of pepsin digestion recommended was substantially the same as described in the Connecticut Station Report for 1893, page 219, and is as follows:

Bring 1 gram of substance into a 150 cc flask, and add 100 cc of pepsin-hydrochloric acid solution. Place the flask, loosely corked, in a water-bath having a constant temperature of 40° C. Digest at this temperature for twenty-four hours, adding 2 cc of a 10 per cent hydrochloric acid solution at the end of the second, fifth, eighth, and eleventh hours. Shake the solution well on each addition of acid. At the end of the digestion transfer the contents of the flask to a filter, wash with 150 to 200 cc of cold water and determine nitrogen by the Kjeldahl method in the residue.

Pepsin-hydrochloric acid solution.—Mix 5 grams of pulverized pepsin (guaranteed to dissolve 2,000 times its weight of coagulated white of egg) in 1,000 cc of hydrochloric acid diluted to a strength of two-tenths per cent.

These analysts have reported results by this method as follows:

Analysts.	4.			5.			6.			7.			8.		
	Per cent total N.	Per cent soluble.	Per cent available.	Per cent total N.	Per cent soluble.	Per cent available.	Per cent total N.	Per cent soluble.	Per cent available.	Per cent total N.	Per cent soluble.	Per cent available.	Per cent total N.	Per cent soluble.	Per cent available.
R. J. Davidson	2.94	2.60	88.4	2.87	2.12	78.9	2.58	*1.07	*41.5	2.46	0.34	13.8	2.01	1.06	50.5
E. H. Jenkins	2.88	2.73	94.8	2.98	2.34	78.5	2.68	1.51	56.3	2.57	.45	17.5	2.15	1.25	58.1
J. P. Street	2.92	2.75	94.2	3.04	2.35	77.3	2.58	1.46	56.6	2.57	.48	18.7	2.03	1.05	51.7
Average	2.91	2.69	92.5	2.96	2.27	76.6	2.61	1.49	56.5	2.53	.42	16.7	2.06	1.12	53.4

* Omitted from average.

When it is remembered that such small quantities of the materials are used, and that a difference of a few hundredths will make a difference of several per cent in the per cent of availability, the above results are extremely satisfactory, and show that the method is capable of giving concordant results in the hands of different analysts. The value of this method, however, must be determined largely by the correspondence of its results with those secured by the vegetation tests. Reducing the data to a comparable basis we have the following:

Percentage of nitrogen.

Sample.	By vegetation test.	By pepsin digestion.
No. 4, blood	46.5	46.5
No. 5, tankage	44.8	38.5
No. 6, hoof	43.4	28.4
No. 7, raw leather	8.4	8.4
No. 8, fertilizer	29.8	27.8

The agreement between the two methods is quite satisfactory, except in the case of hoof meal. These tests confirm what Dr. Jenkins has already shown, namely, that the amount of nitrogen dissolved by pepsin is no measure of the availability of the nitrogen of hoof meal.

HAYES PERMANGANATE OF POTASH METHOD.

This method was suggested in a paper read at the last meeting of this association, and consists of treating 1 gram of material in a flask with 100 cc of potassium permanganate solution containing 16 grams $KMnO_4$ and 200 grams KOH per liter. Digest at a low temperature for one hour, then increase the temperature and distill for one hour, and titrate as usual.

The reporter was not able, from lack of time, to give the method an extended test before sending out samples, and since then has been able to do little additional work for the same reason. However, the few results obtained by Mr. Davidson and myself seem to indicate that there are possibilities in the method and that it is worthy of future study.

The following tabulation shows how the results secured agree with those by the vegetation tests:

Percentage of nitrogen.

Sample.	Davidson.	Alkaline, Street.	Solution, average.	Acid solution, Davidson.	Vegetation tests.
No. 4	46.5	46.5	46.5	46.5	46.5
No. 5	50.4	42.2	46.3	47.6	44.8
No. 6	58.2	51.4	54.8	41.8	43.4
No. 7	23.7	24.7	24.2	13.6	8.4
No. 8	35.8	32.3	34.0	33.6	29.8

The average results compared with the vegetation tests agree fairly, showing the method to give rather high results on hoof meal and raw leather, but approaching the truth nearer than the pepsin method. Mr. Davidson also made some tests where an acid solution of permanganate was used. His results are included in the above table and show quite a remarkable agreement with the vegetation tests. The method promises well and is worthy of further study in connection with other nitrogenous materials.

RECOMMENDATIONS

1. That the Ulsch-Street method for the determination of nitric nitrogen in mixed fertilizers be made an official method.

2. That the Fassbender method for the determination of total nitrogen be made an official method.

3. That the nitrogen reporter for 1897 be requested to investigate further the permanganate of potash method for determining the availability of organic nitrogen; also, the Ulsch method for determining nitrates in nitrate salts.

4. That it is the sense of this association that in reporting fertilizer analyses its members should indicate whether the nitrogen present exists as nitrates, ammonia, or as organic matter.

5. That a method for the qualitative determination of nitric nitrogen in fertilizers be included under the nitrogen methods.

AMENDED AND ADOPTED REPORT OF THE COMMITTEE ON RECOMMENDATIONS IN RELATION TO NITROGEN.

It is recommended—

(1) That the Ulsch-Street method be referred to the reporters for the next year, to be further tested with special reference to nitrates.

(2) That the method heretofore referred to as the Fassbender method be referred to the reporters for the next year for further trial, with request that they look up the question of whether the method should legitimately be called the Fassbender method or should be otherwise designated.

(3) That the Hayes permanganate method of determining the availability of organic nitrogen be referred to next year's reporters for further trial.

(4) That the following resolution be adopted: *Resolved*, That it is the sense of this association that the forms of the nitrogen in commercial fertilizers should be reported where it is possible to do so.

(5) That the qualitative method for the detection of nitrates by use of ferrous sulphate be adopted.

(6) That the comparison of the Tiemann-Schulze and Ulsch-Street methods for nitrates be referred to the reporters on nitrogen for 1897.

(7) That on page 21 under (*h*), third line from the top of the paragraph, be substituted for the words "a large excess of magnesia" the following: "5 grams or more of magnesium oxid free from CO_2.

H. J. WHEELER,
For Committee on Reporters' Recommendations.

The **PRESIDENT.** It is customary to appoint a committee to wait upon the Secretary and Assistant Secretary of Agriculture and invite them to attend our meetings. In accordance with the custom I will appoint Messrs. Frear and Lindsey on that committee.

Are there any papers on the subject of the determination of nitrogen?

Mr. **SWEETSER** presented the following:

COMPARISON OF NITROGEN DETERMINATION BY THE KJELDAHL METHOD, DISTILLING WITH AND WITHOUT POTASSIUM SULPHID.

By W. S. SWEETSER.

The average of 53 determinations of nitrogen in a miscellaneous lot of fertilizers by the official Kjeldahl method was 1.59 per cent, and by distilling without potassium sulphid, 1.61 per cent. With the official method as the basis, the omission of the potassium sulphid solution gave higher results in 29, lower in 10, and the same in 14 cases out of the 53. In 36 cases the variation was less than 0.05 of 1 per cent.

The distillations were made in copper flasks without the addition of zinc. The samples consisted of mixed fertilizers and a few ground bones. Some contained nitrates in abundance, and these were done by the Scovell method.

The results in all cases seem to indicate that the addition of potassium sulphid is unnecessary, especially when copper distilling flasks are used.

There being no additional papers on the subject of nitrogen determination, the President asked for the reading of the recommendations of the reporter. They were read as given above.

Mr. **STREET.** I desire to call special attention to the recommendation concerning the various forms of nitrogen, and to the importance of the analyst determining in what particular form the nitrogen exists.

The **PRESIDENT.** It is now in order to discuss the report and recommendations. The latter will be referred to the committee on recommendations, according to the regular order.

Mr. **HUSTON.** The reporter comments on the fact that the Ulsch-Street method gives poorer results in sample No. 1, and better in Nos. 2 and 3. This, however, is only apparently so, for when judged by the percentage of error the results in No. 1 are better than Nos. 2 and 3. The percentage of the error and the actual magnitude of the error should always be considered.

Mr. **Winton.** I like the Ulsch-Street method for mixed fertilizers. I would also be glad to see the Schulze-Tiemann process tried, and would like the reporter next year to consider that method. It has been used very extensively, both here and in Europe, and it does not seem to me we should let so good a method fall into disuse.

Mr. **Wheeler.** I have used the Schulze-Tiemann method, and have an impression that it was once adopted as a provisional method for this association, but am not certain. Perhaps someone can give me some definite information on the subject.

The **President.** It seems to me that the Schulze-Tiemann method should be given a trial by the reporter next year.

Mr. **Kilgore.** The Schulze-Tiemann method was adopted as a provisional method two years ago, and, having been so adopted, it may come properly before the association for adoption as a regular method.

Mr. **Winton.** I would like an expression of opinion in regard to the Schulze-Tiemann method. How many present have used this method?

Several members responded affirmatively.

Mr. **Street.** I would gladly include the Schulze-Tiemann method among my recommendations as one which should be further tried and possibly adopted by the association.

The **President.** By common consent the Schulze-Tiemann method will be considered by the committee on recommendations of reporters.

Mr. **Huston.** I would like to know if it be necessary, as directed in the methods of analysis, to use a flat-bottomed flask in nitrogen determinations by the Ulsch-Street method.

Mr. **Street.** It is not necessary; it is only a matter of convenience.

Mr. **Huston.** Sometimes mere details of description which are not important become official, and the analyst feels compelled to follow even the minutiæ of the description, when any little variation therefrom would be of no importance, and often prove a great convenience.

Mr. **Kilgore.** I suggest that Mr. Winton furnish the committee on recommendations of reporters a description of the Schulze-Tiemann method.

Mr. **Gaines.** I have had considerable trouble with the breaking of flasks during distillation. About one-half the flasks, in my experience, break in distilling. I should like to know how this breakage can be avoided. It is a difficulty I am puzzled to account for.

Mr. **Goss.** In the determination of the nitrogen in soils the size of the flask should be taken into consideration. If the flask is large enough there will be very little trouble with bumping, and the bumping in the flask is usually the cause of the breakage.

Mr. **Street.** It is also important to get the right kind of flasks. If you do this you will have very little trouble by breaking. In making 400 analyses I have only broken six flasks.

Mr. **Gaines.** May I ask Mr. Street if he transfers the material from the digesting flask to a separate flask for distillation?

Mr. Street. We never transfer from one flask to another. We make the distillation in the same flask in which the digestion in sulphuric acid is accomplished.

Mr. Van Slyke. I use the Jena glassware. While it is more expensive at first, I find it cheaper in the end, and it gives most excellent satisfaction, and the amount of breakage is reduced to the minimum.

The President. When a little zinc dust is used during the distillation I have found very little trouble from the breaking of flasks.

Mr. Wheeler. Often the addition of a little more caustic soda will avoid bumping and consequent breaking of the flask.

The President. If there is no further discussion of the report on nitrogen the recommendations therein made will be referred to the committee on recommendations of reporters for their consideration. I will now call for the report on potash.

Mr. Winton. Mr. President, I beg leave to submit the following report:

REPORT ON POTASH.

By A. L. Winton, *Reporter.*

The reporter on potash for the years 1894 and 1895, Mr. H. J. Wheeler, realized the importance of learning more with regard to our old methods before taking up the various new methods which had not yet been tried by the association, and accordingly confined the work carried on during the two years to a thorough investigation of the Lindo-Gladding and "optional" methods as applied to mixed fertilizers. Since in this country the larger part of the potash which is sold to the farmer is contained in mixed fertilizers, it was desirable that our methods for the analysis of these goods be first tested.

This work accomplished it was thought proper during the present year to carry on a similar investigation with German potash salts.

Incidentally a study was made of factors for the conversion of potassium platinichlorid into potassium sulphate, chlorid, and oxid.

Investigation of Methods for Determination of Potash in German Potash Salts.

Although, as has been stated, the potash applied to our soils is largely contained in mixed fertilizers, still it is practically all brought into the country in the form of four German potash salts. It is then on the salts themselves that the analyses of European and American chemists are most frequently compared, and any discrepancies in the results are too often attributed to inaccuracies in our methods.

Before going into the details of the work carried on during the year, it may be well to consider the principles which underlie the "optional," Stassfurt, and Lindo-Gladding methods.

Our so-called "optional method" is really but a modification of a method which in one form and another has for many years been employed in general analytical chemistry. The salient feature is the separation of sulphuric acid and all bases but potash and soda previous to evaporation with platinum solution. This necessitates several precipitations, the evaporation of a considerable bulk of liquid and ignition for removal of ammonium salts, thus making the process a very tedious one. Since barium sulphate is apt to carry down with it a considerable amount of potash, the results are usually low.

The "shorter method" devised by Fresenius[1] and in a slightly modified form[2] employed under the name of the "Stassfurt method" in the laboratories of the

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[1] Quant. Analyse, 6 Aufl. II, 292.

[2] Ztschr. Angew. Chem., 1895.

Stassfurt syndicate and the German experiment stations, is really a simplification of the foregoing method. It depends on the fact that if sulphuric acid be removed from the solution of a potash salt, the liquid may be evaporated directly with platinum solution, chlorids of magnesium, calcium and sodium forming alcohol-soluble salts with chloroplatinic acid. It is claimed that if the precipitation of barium sulphate be carried on in an acid solution and with certain precautions, loss of potash is avoided.

The Lindo-Gladding method has been developed by the successive labors of Finkener,[1] Lindo,[2] Gladding,[3] and members of this association. The solution in which potash is to be determined is evaporated with platinum solution without previous separation of bases or sulphuric acid, the sulphates which contaminate the potassium platinichlorid being subsequently removed by ammonium chlorid solution. The method is rapid and, as will be seen later, remarkably accurate.

During the year only the two methods recognized by the association have been studied by American chemists, but in three of the laboratories connected with the Stassfurt industry, comparative analyses were made by the Lindo-Gladding and Stassfurt methods.

PLAN OF INVESTIGATION.

Instead of working with the German salts themselves, the potash content of which could only be learned by recourse to the very methods which it sought to test, or with artificial German salts containing a known proportion of potash from pure salts, which, however, are liable to lack uniformity and change in composition through loss of moisture, the plan followed by Mr. Wheeler was adopted which obviates all these disadvantages.

In each determination a carefully weighed portion of chemically pure potash salt was employed and to this was added a solution of the other water-soluble ingredients in the proportion contained in the material, the analysis of which it was desired to imitate. Such a solution contains the same ingredients as a solution of the commercial potash salt, but the exact quantity of potash present is definitely known without analysis.

PREPARATION OF MATERIALS.

The statements of the average composition of the Stassfurt salts, given in a pamphlet issued by the German Kali Works, served as a basis for the preparation of the solutions of analysis representing these salts. (See Table I.)

TABLE I.—*Average composition of German potash salts.*

[Taken from "Potash; origin, trade and its use in agriculture," Columbian Exposition, Chicago, German Kali Works.]

	K_2SO_4.	KCl.	$MgSO_4$.	$MgCl_2$.	NaCl.	$CaSO_4$.	Substances insoluble in water.	Water.	K_2O.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Kainit	21.3	2.0	14.5	12.4	34.6	1.7	0.8	12.7	12.8
Sulphate of potash, 90 per cent.	90.6	1.6	2.7	1.0	1.2	0.4	0.3	2.2	49.9
Sulphate of potash—magnesia	50.4	....	34.0	....	2.5	0.9	0.6	11.6	27.2
Muriate of potash, 80 to 85 per cent.	....	83.5	0.4	0.3	14.5	....	0.2	1.1	52.7

Both potassium chlorid and sulphate were used in the work. The former was from the same lot as that employed in last year's work, and contained 0.45 per cent of water, which being included in the crystals could only be determined by heating nearly to redness in a well-covered crucible. Included water was also contained in the potassium sulphate when received from the dealer, but in this case the whole quantity was ignited by the reporter until entirely anhydrous. There was every evidence that both salts were absolutely pure.

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[1] Pogg. Ann. 29. 627.

[2] Chem. News, 44, pp. 77, 86, 97 and 129.

[3] U. S. Department of Agriculture, Bulletin No. 7, p. 38.

The other salts used were chemically pure with one exception. The reporter found that "magnesium chlorid chemically pure," from no less than four manufacturers, contained so considerable a quantity of potash as to be valueless for the work. After some search a cheaper grade of the salt was obtained, which, although not claimed to be pure, was almost entirely free from potash, and therefore better suited for the purpose than the so-called chemically pure salts. It contained the normal quantity of water of crystallization—6 molecules.

The magnesium sulphate was recrystallized Epsom salts with 7 molecules of water. The sodium chlorid and calcium sulphate were not only pure but anhydrous.

Four mixtures of impurities representing the water-soluble ingredients, other than potash, of the four manure salts were prepared by mixing the salts just named in the proportions given in Table 1, allowing for water of crystallization when present. These mixtures were then weighed into portions, representing in each case the impurities in 10 grams of the manure salt, and bottled.

A bottle of each of these, together with portions of the pure potash salts, were sent out to each chemist with the following instructions:

INSTRUCTIONS FOR THE WORK.

Determinations of potash should first be made on the pure potash salts, using tested reagents, and the results compared with the theoretical composition. The total quantity of each of the mixtures of impurities should be boiled with 200 to 300 cc of water, made up to 500 cc and filtered through a dry paper. Solutions for analysis, representing 0.5 gram of the several Stassfurt products are prepared as follows:

Kainit: Dissolve about 0.14 gram K_2SO_4 in 25 cc kainit impurities.

Sulphate potash, 90 per cent: Dissolve about 0.46 gram K_2SO_4 in 25 cc sulphate potash.

Sulphate potash and magnesia: Dissolve about 0.26 gram K_2SO_4 in 25 cc sulphate potash and magnesia.

Muriate potash, 80 per cent: Dissolve about 0.42 gram KC_1 in 25 cc muriate of potash.

The pure potash salts should be weighed with the greatest accuracy from weighing tubes, taking care to have the quantities within a few centigrams of those given above—better more than less. Solutions thus prepared should be used in testing the alternate method and also in testing the Lindo-Gladding method, as applied to all the salts except kainit. In the analysis of this latter salt by the official Lindo-Gladding method lime is first separated, although in the original method as described by Gladding and followed for several years by the association, the evaporation with platinum solution was made directly. De Roode (J. Am. Chem. Soc. 17, 85) finds separation of lime unnecessary.

You are requested first to follow the same method for kainit as for sulphate of potash and magnesia, on solutions prepared as described, then, if desirable, make determinations with separation of lime as follows: Place a carefully weighed portion of about 0.28 gram K_2SO_4 and 50 cc kainit impurities in a 100 cc flask, add ammonia and ammonium oxalate, make up to 100 cc, filter through a dry paper, and proceed with 50 cc according to the official method for kainit.

If you undertake a study of the Stassfurt methods (Ztschr. Angew. Chem., 1895, Heft 17), it is recommended, in order to avoid waste of material, that the pure salt and solution of impurities be taken in each case in such quantities as to correspond to one-fifth (or for kainit, method C. 2, to one-twentieth) the quantity of the Stassfurt product which in loc. cit. it is directed should be weighed out, using correspondingly smaller quantities of reagents and making up to a correspondingly smaller volume. In this way the aliquot portion after separation of $BaSO_4$ may be made to represent the same quantity of material as it would if the directions were strictly followed.

Blank determinations should be made by the methods investigated on the solution of impurities, using the same quantities of reagents as in the actual analysis.

In reporting results please give (1) weight of pure salt employed, (2) total weight K_2PtCl_6 found, and (3) weight of K_2PtCl_6 from reagents and "impurities."

Twenty-six sets of materials were sent to American chemists who expressed an interest in the work. Of these seven found opportunity for conducting the analyses.

At the suggestion of Dr. von Herff, ten sets were sent to the New York office of the Kali Syndicate from whence six were forwarded to German experiment stations and four to laboratories connected with the Stassfurt industry.

No communication has been received from the German stations, but Dr. Tietjens reports results obtained in the laboratory of the syndicate and at two of the salt mines.

RESULTS SECURED BY AMERICAN CHEMISTS.

The following chemists took part in the study of the Lindo-Gladding and "optional" methods:

Mr. B. B. Ross, State chemist, Auburn, Ala.
Mr. F. B. Bomberger, laboratory of State chemist, Maryland Agricultural College, College Park, Md.
Mr. W. G. Brown, United States Department of Agriculture, Washington, D. C.
Mr. C. G. Hopkins, Illinois Experiment Station, Urbana, Ill.
Mr. G. W. Cavanaugh, Cornell Experiment Station, Ithaca, N. Y.
Mr. C. H. Jones, Vermont Experiment Station, Burlington, Vt.
Mr. F. S. Shiver, Clemson Experiment Station, Clemson College, S. C.

In Table II are given the weights of the pure salts taken, of the total K_2PtCl_6 found and of the K_2PtCl_6 from "impurities" and reagents. These figures furnish the data for the calculation given in the subsequent tables. It should be noted that although the impurities were almost entirely free from potash, several of the analysts obtained K_2PtCl_6 in blank determinations on the reagents and impurities, which was probably due to potash in the reagents. This was particularly marked when the optional method was followed. This same experience was encountered in last year's work, and illustrates the importance of testing reagents by blank determinations, since "chemically pure" salts when carefully examined are often found to contain impurities.

TABLE II.—*Analytical data from American chemists.*

	Lindo-Gladding method.			Optional method.		
	Pure salt taken.	K_2PtCl_6 total found.	K_2PtCl_6 reagents and impurities.	Pure salt taken.	K_2PtCl_6 total found.	K_2PtCl_6 reagents and impurities.
Potassium chlorid c. p.:	*Gram.*	*Gram.*	*Gram.*	*Gram.*	*Gram.*	*Gram.*
F. B. Bomberger	0.2500	0.8141	0.0035	....	....	....
	.2500	.8158	....	....	....	....
	.2500	.8168	....	....	....	....
W. G. Brown	.4586	1.4882	.0003	[1] 0.3998	[2] 1.3027	0.0003
	.6824	2.2169	....	[2] .4836	1.5676	....
	.4653	1.5100	....	[2] .4343	1.4074	....
	.3959	1.2941	....	.4569	1.4782	....
	....	....	....	.4508	1.4487	....
G. W. Cavanaugh	....	....	....	.4821	1.5720	....
	....	....	....	.3947	1.2908	....
C. H. Jones	.5000	1.6265	.0025	.5000	1.6240	.0070
	.5000	1.6295	....	.5000	1.6214	....
	.5000	1.6295	....	....	....	....
F. S. Shiver	....	....	....	[2] .1671	.5433	.0000
A. L. Winton	....	....	....	[2] .6096	1.9793	.0000
	....	....	....	[2] .5400	1.7512	....
Muriate of potash (KCl c. p. + impurities):						
B. B. Ross	[1] .2100	.6930	.0068	....	....	....
	[1] .2100	.6916	....	....	....	....

[1] Anhydrous salt.

[2] Direct evaporation with platinum solution.

TABLE II.—*Analytical data from American chemists*—Continued.

	Lindo-Gladding method.			Optional method.		
	Pure salt taken.	K_2PtCl_6 total found.	K_2PtCl_6 reagents and impurities.	Pure salt taken.	K_2PtCl_6 total found.	K_2PtCl_6 reagents and impurities.
Muriate of potash (KCl c. p. + impurities)—Continued.	*Gram.*	*Gram.*	*Gram.*	*Gram.*	*Gram.*	*Gram.*
F. B. Bomberger	.4516	1.4712	.0065	.1563	.5197	.0168
	.4706	1.5315	....	.1563	.5182	....
W. G. Brown	.4059	1.3226	.0001	.4310	1.3937	.0010
	.5036	1.6379	....	.4814	1.5508	.0005
G. W. Cavanaugh	.4439	1.4535	....	.4228	1.3806	.0027
C. G. Hopkins	.4555	1.4802	.0005	[1] .4206	1.3600	.0013
	.4318	1.4020	.0005	[1] .4205	1.3602	.0007
C. H. Jones	.4215	1.3754	.0045	.4200	1.3740	.0100
	.4220	1.3765	....	.4200	1.3718	....
F. S. Shiver	.4261	1.3822	.0001	.4214	1.3815	.0062
A. L. Winton	.4290	1.3915	.0003	....	....	....
	.3948	1.2780	....	....	....	....
Potassium sulphate c. p.:						
F. B. Bomberger	.2500	.7011	.0035	.1310	.3804	.0173
	.2500	.7002	....	.1310	.3803	....
	.2500	.6995	....	....	....	....
W. G. Brown	.5649	1.5795	.0003	.5121	1.4080	.0003
	.6011	1.6794	....	.4822	1.3227	....
G. W. Cavanaugh	.4836	1.3566	....	....	....	....
	.4842	1.3565	....	....	....	....
C. H. Jones	.5000	1.3987	.0025	.5000	1.3915	.0075
	.5000	1.3990	....	.5000	1.3940	....
F. S. Shiver	....	....	....	.1648	.4589	.0000
A. L. Winton	....	....	....	[2] .4725	1.3223	.0000
	....	....	....	[2] .4942	1.3786	....
	....	....	....	[2] .4185	1.1700	....
	....	....	....	[2] .4679	1.3064	....
Sulphate of potash, 90 per cent (K_2SO_4 c. p. + impurities):						
F. B. Bomberger	.3930	1.1002	.0049	.1310	.3814	.0187
	.4092	1.1389	....	.1310	.3818	....
	.4624	1.2917	....	....	....	....
W. G. Brown	.5130	1.4337	.0003	.6171	1.6898	.0020
	.4517	1.2632	....	.4371	1.2124	.0025
G. W. Cavanaugh	.4745	1.3319	.0039	.4506	1.2469	....
C. G. Hopkins	.4674	1.3055	.0008	[1] .4604	1.2744	.0013
	.4563	1.2730	.0008	[1] .4603	1.2700	.0013
C. H. Jones	.4640	1.2980	.0040	.4600	1.2810	.0095
	.4645	1.2960	....	.4600	1.2835	....
A. L. Winton	.4042	1.1248	.0005	....	....	....
	.4121	1.1483	....	....	....	....
	.4110	1.1448	....	....	....	....
Sulphate of potash and magnesia (K_2SO_4 + impurities):						
F. B. Bomberger	.2670	.7494	.0055	.1310	.3782	.0180
	.2785	.7808	....	.1310	.3797	....
	....	....	....	.1310	.3780	....

[1] See Mr. Hopkins's notes.

[2] Direct evaporation with platinum solution.

TABLE II.—*Analytical data from American Chemists*—Continued.

	Lindo-Gladding method.			Optional method.		
	Pure salt taken.	K_2PtCl_6 total found.	K_2PtCl_6 reagents and impurities.	Pure salt taken.	K_2PtCl_6 total found.	K_2PtCl_6 reagents and impurities.
Sulphate of potash and magnesia (K_2SO_4 + impurities)—Continued.	*Gram.*	*Gram.*	*Gram.*	*Gram.*	*Gram.*	*Gram.*
W. G. Brown	.2680	.7508	.0021	.2676	.7318	.0033
	.3301	.9252	....	.2509	.6854	.0027
G. W. Cavanaugh	....	....	....	.2652	.7371	....
C. G. Hopkins	.2617	.7302	.0007	[1].2610	.7295	.0017
	.2553	.7124	.0007	[1].2604	.7260	.0017
C. H. Jones	.2645	.7434	.0035	.2600	.7240	.0090
	.2640	.7400	....	.2600	.7248	....
F. S. Shiver	.2650	.7358	.0000	.2632	.7374	.0151
A. L. Winton	.3040	.8470	.0009	....	....	....
	.2686	.7490	....	....	....	....
	.2566	.7136	....	....	....	....
Kainit (K_2SO_4 c. p. + impurities):						
B. B. Ross	[2].1400	.3950	.0044	....	....	....
	[2].1400	.3941	.0044	....	....	....
F. B. Bomberger	.1390	.3898	.0040	.1310	.3798	.0153
	.1310	.3684	....	.1310	.3801	....
	.1310	.3674	....	....	....	....
W. G. Brown	[2].2009	.5624	.0034	.3700	1.0217	.0028
	[2].1555	.4377	....	.1395	.3889	.0047
	.1460	.4070	....	[3].4180	1.3394	....
	.1871	.5190	....	[3].4427	1.4416	....
G. W. Cavanaugh	.1464	.4004	.0044	.1543	.4287	....
C. G. Hopkins	.1518	.4226	.0007	[1].1405	.3946	.0021
	.1571	.4381	.0006	[1].1407	.3946	.0025
C. H. Jones	[2].1460	.4090	.0030	.1400	.3962	.0105
	[2].1460	.4080	....	.1400	.4010	....
	.1445	.4022	.0035	....	....	....
	.1445	.4030	....	....	....	....
F. S. Shiver	.1433	.3968	.0000	.1444	.4081	.0097
A. L. Winton	[2].1387	.3860	.0013	....	....	....
	[2].1727	.4807	....	....	....	....

[1] See Mr. Hopkins's notes.
[2] Direct evaporation without previous separation of lime.
[3] Potassium chlorid.

Mr. Ross sent the following notes with his figures:

The Lindo-Gladding process, as originally employed by the association, was used as regards the preliminary treatment of the solution without any attempt being made to precipitate the lime, etc., by addition of NH_4HO and $(NH_4)_2C_2O_4$.

After weighing the precipitates they were dissolved off the filter with hot water and the loss on reweighing noted. The proportion of impurities left undissolved by the NH_4Cl wash solution was quite small, but for accuracy's sake the loss on dissolving in hot H_2O was noted. In several cases this aqueous solution of K_2PtCl_6 was evaporated on a water bath and the residue dried. When dried at 100° C. the residue invariably weighed more than the loss in weight noted on dissolving the contents of the filter in hot H_2O. On drying at 120° to 130° C. the excess in this weight soon disappeared.

Although I have made quite a number of determinations in two or three of the salts by the alternate method, I do not feel justified in reporting some of these (which are too low in almost every case), for the reason that I had numerous interruptions during this part of the work. My experience with the alternate method has always been that it is difficult to so adjust the flame used in the final ignition of the residue (obtained by evaporation) as to secure complete volatilization of ammonium compounds and at the same time to avoid loss of KCl.

Mr. Brown wrote as follows:

I have followed your instructions as far as they were given, except where otherwise noted, but in the matter of detail I may have done differently from some of the other workers. To explain: In evaporating the solution of the potassium salt after the addition of the platinum chlorid I have been careful to get rid of the excess of hydrochloric acid, in some cases adding water and evaporating two or three times until the odor of hydrochloric acid was hardly perceptible. At present there are no directions for the treatment of the dried mass with alcohol. I added the alcohol to the mass and kept it only so long in contact with the salts as it seemed to be dissolving them, pouring off the solution through the Gooch crucible or filter, adding fresh alcohol and continuing to treat with alcohol until it came away nearly colorless before transferring the potassium chlorplatinate to the Gooch crucible or filter. In five minutes after adding the alcohol it was frequently decanted off. I found it necessary to use about 100 cc of alcohol for each determination, usually somewhat more than less. The potassium chlorplatinate was in all cases dried in the steam bath at 100° (the temperature is not given in the "Methods of analysis" for the Lindo-Gladding method), except in two experiments, where, after having been dried in the steam bath, it was treated in the air bath at 130° for about three hours, when it was found that the weight was unchanged. In two of the determinations by the optional method there were added to the potassium chlorid kainit impurities, instead of muriate of potash impurities, and the determination of potassium chlorplatinate was made under these conditions.

In one of the sulphate of potash determinations by the optional method instead of 0.46 gram potassium sulphate 0.62 gram was taken and 50 cc of impurities.

In all the determinations except two by the optional method the potassium chlorplatinate was weighed in Gooch crucibles. In these two the potassium chlorplatinate was collected on paper, dissolved off the paper with hot water, caught in a platinum dish, evaporated, dried, and weighed in the dish.

Mr. Hopkins stated that—

In the optional method where heavy precipitates were formed by adding BaCl and Ba(OH)$_2$ they were washed twice by ordinary decantation. Then they were rubbed up with about 5 grams of purified sand and shaken well with hot water, which was decanted after the precipitate settled. This was continued until washings free from chlorids were obtained.

The remainder of the figures were reported without comment, other than those given with the tables.

TABLE III.—*Results from American chemists corrected for potash in reagents and "impurities," calculated by old factors.*

	Lindo-Gladding method.				Optional method.			
	Taken KCl.	Found KCl.	Error KCl.	Error K_2O.	Taken KCl.	Found KCl.	Error KCl.	Error K_2O.
Potassium chlorid c. p.:	*Gram.*	*Gram.*	*Gram.*	*Gram.*	*Gram.*	*Gram.*	*Gram.*	*Gram.*
F. B. Bomberger	0.2489	0.2477	—0.0012	—0.0008	....	....	....	....
	.2489	.2482	— .0007	— .0004	....	....	....	....
	.2489	.2485	— .0004	— .0003	....	....	....	....
W. G. Brown	.4565	.4547	— .0018	— .0011	[1]0.3998	0.3980	—0.0018	—0.0011
	.6793	.6774	— .0019	— .0012	[1].4814	.4790	— .0024	— .0015
	.4632	.4614	— .0018	— .0011	[1].4324	.4300	— .0024	— .0015
	.3941	.3954	+ .0013	+ .0008	.4548	.4516	— .0032	— .0020
	....	....	....	....	.4488	.4426	— .0062	— .0039
G. W. Cavanaugh	....	....	....	....	.4799	[2].4804	+ .0005	+ .0003
	....	....	....	....	.3980	[2].3944	+ .0014	+ .0009
C. H. Jones	.4978	.4963	— .0015	— .0010	.4978	.4942	— .0036	— .0023
	.4978	.4972	— .0006	— .0004	.4978	.4934	— .0044	— .0028
	.4978	.4972	— .0006	— .0004	....	....	....	....

[1] Direct evaporation with platinum solution.

[2] No blank determinations made, hence results not corrected.

TABLE III.—*Results from American chemists corrected for potash in reagents and "impurities," calculated by old factors*—Continued.

	Lindo-Gladding method.				Optional method.			
	Taken KCl.	Found KCl.	Error KCl.	Error K_2O.	Taken KCl.	Found KCl.	Error KCl.	Error K_2O.
Potassium chlorid c. p.—Continued.	*Gram.*	*Gram.*	*Gram.*	*Gram.*	*Gram.*	*Gram.*	*Gram.*	*Gram.*
F. S. Shiver	....	....	....	....	[1].1664	.1660	— .0004	— .0002
A. L. Winton	....	....	....	....	[1].6069	.6049	— .0020	— .0013
	....	....	....	....	[1].5376	.5352	— .0024	— .0015
Muriate of potash, 80 to 85 per cent (KCl c. p. + impurities):								
B. B. Ross	.2100	.2097	— .0003	— .0002	....	....	....	....
	.2100	.2093	— .0007	— .0004	....	....	....	....
F. B. Bomberger	.4496	.4476	— .0020	— .0013	.1556	.1537	— .0019	— .0012
	.4685	.4660	— .0025	— .0016	.1556	.1532	— .0024	— .0015
W. G. Brown	.4041	.4042	+ .0001	+ .0001	.4291	.4257	— .0034	— .0021
	.5013	.5005	— .0008	— .0005	.4792	.4737	— .0055	— .0035
G. W. Cavanaugh	.4419	[2].4442	+ .0023	+ .0014	.4209	.4211	+ .0002	+ .0001
C. G. Hopkins	.4534	.4522	— .0012	— .0008	[3].4187	.4153	— .0034	— .0021
	.4299	.4283	— .0016	— .0010	[3].4186	.4154	— .0032	— .0020
C. H. Jones	.4196	.4189	— .0007	— .0004	.4181	.4168	— .0013	— .0008
	.4201	.4193	— .0008	— .0005	.4181	.4162	— .0019	— .0012
F. S. Shiver	.4242	.4224	— .0018	— .0011	.4195	.4203	+ .0008	+ .0005
A. L. Winton	.4271	.4251	— .0020	— .0013	....	....	....	....
	.3930	.3905	— .0025	— .0016	....	....	....	....

	Lindo-Gladding method.				Optional method.			
	Taken K_2SO_4.	Found K_2SO_4.	Error K_2SO_4.	Error K_2O.	Taken K_2SO_4.	Found K_2SO_4.	Error K_2SO_4.	Error K_2O.
Potassium sulphate c. p.:	*Gram.*	*Gram.*	*Gram.*	*Gram.*	*Gram.*	*Gram.*	*Gram.*	*Gram.*
F. B. Bomberger	0.2500	0.2490	—0.0010	—0.0005	0.1310	0.1296	—0.0014	—0.0008
	.2500	.2487	— .0013	— .0007	.1310	.1296	— .0014	— .0008
	.2500	.2485	— .0015	— .0008	....	....	....	....
W. G. Brown	.5649	.5638	— .0011	— .0006	.5121	.5025	— .0096	— .0051
	.6011	.5994	— .0017	— .0009	.4822	.4721	— .0101	— .0054
G. W. Cavanaugh	.4836	[2].4843	+ .0007	+ .0004	....	....	....	....
	.4842	[2].4843	+ .0001	+ .0001	....	....	....	....
C. H. Jones	.5000	.4984	— .0016	— .0009	.5000	.4941	— .0059	— .0032
	.5000	.4986	— .0014	— .0008	.5000	.4950	— .0050	— .0027
F. S. Shiver	....	....	....	....	.1643	.1638	— .0005	— .0003
A. L. Winton	....	....	....	....	[1].4725	.4720	— .0005	— .0003
	....	....	....	....	[1].4942	.4922	— .0020	— .0011
	....	....	....	....	[1].4185	.4177	— .0008	— .0004
	....	....	....	....	[1].4679	.4664	— .0015	— .0008
Sulphate of potash, 90 per cent (K_2SO_4 c. p.+impurities):								
F. B. Bomberger	.3930	.3910	— .0020	— .0011	.1310	.1295	— .0015	— .0008
	.4092	.4048	— .0044	— .0024	.1310	.1296	— .0014	— .0007
	.4624	.4594	— .0030	— .0016	....	....	....	....
W. G. Brown	.5130	.5117	— .0013	— .0007	.6171	.6024	— .0147	— .0089
	.4517	.4509	— .0008	— .0004	.4371	.4320	— .0051	— .0028
G. W. Cavanaugh	.4745	.4741	— .0004	— .0002	[2].4506	.4452	— .0054	— .0029

[1] Direct evaporation with platinum solution.

[2] No blank determinations made, hence results not corrected.

[3] See Mr. Hopkins's notes.

TABLE III.—*Results from American chemists corrected for potash in reagents and "impurities," calculated by old factors*—Continued.

	Lindo-Gladding method.				Optional method.			
	Taken K_2SO_4.	Found K_2SO_4.	Error K_2SO_4.	Error K_2O.	Taken K_2SO_4.	Found K_2SO_4.	Error K_2SO_4.	Error K_2O.
Sulphate of potash, 90 per cent (K_2SO_4 c. p. + impurities)—Continued.	*Gram.*	*Gram.*	*Gram.*	*Gram.*	*Gram.*	*Gram.*	*Gram.*	*Gram.*
C. G. Hopkins	.4674	.4658	— .0016	— .0009	[1].4604	.4545	— .0059	— .0032
	.4563	.4542	— .0021	— .0011	[1].4603	.4529	— .0074	— .0040
C. H. Jones	.4640	.4620	— .0020	— .0011	.4600	.4539	— .0061	— .0033
	.4645	.4612	— .0033	— .0018	.4600	.4548	— .0052	— .0028
A. L. Winton	.4042	.4014	— .0028	— .0015				
	.4121	.4098	— .0023	— .0012				
	.4110	.4085	— .0025	— .0014				
Sulphate of potash and magnesia (K_2SO_4 c. p. + impurities):								
F. B. Bomberger	.2670	.2656	— .0014	— .0008	.1310	.1286	— .0024	— .0013
	.2785	.2768	— .0017	— .0009	.1310	.1291	— .0019	— .0010
					.1310	.1285	— .0025	— .0014
W. G. Brown	.2680	.2673	— .0007	— .0004	.2676	.2602	— .0074	— .0040
	.3301	.3295	— .0006	— .0003	.2509	.2436	— .0073	— .0039
G. W. Cavanaugh					[2].2652	.2631	— .0021	— .0012
C. G. Hopkins	.2617	.2604	— .0013	— .0007	[1].2610	.2598	— .0012	— .0006
	.2553	.2541	— .0012	— .0006	[1].2604	.2586	— .0018	— .0010
C. H. Jones	.2645	.2642	— .0003	— .0002	.2600	.2553	— .0047	— .0025
	.2640	.2629	— .0011	— .0006	.2600	.2555	— .0045	— .0024
F. S. Shiver	.2650	.2627	— .0023	— .0012	.2632	.2579	— .0053	— .0029
A. L. Winton	.3040	.3021	— .0019	— .0010				
	.2686	.2671	— .0015	— .0008				
	.2566	.2544	— .0022	— .0012				
Kainit (K_2SO_4 c. p. + impurities):								
B. B. Ross	[3].1400	.1394	— .0006	— .0003				
	[3].1400	.1391	— .0009	— .0005				
F. B. Bomberger	.1390	.1377	— .0013	— .0007	.1310	.1301	— .0009	— .0005
	.1310	.1301	— .0009	— .0005	.1310	.1302	— .0008	— .0004
	.1310	.1297	— .0013	— .0007				
W. G. Brown	[3].2009	.1996	— .0013	— .0007	.3700	.3634	— .0066	— .0036
	[3].1555	.1550	— .0005	— .0003	.1395	.1375	— .0020	— .0011
	.1460	.1441	— .0019	— .0010	[4].4161	.4082	— .0079	— .0043
	.1871	.1841	— .0030	— .0016	[4].4407	.4394	— .0013	— .0007
G. W. Cavanaugh	.1464	.1414	— .0050	— .0027	[2].1543	.1530	— .0013	— .0007
C. G. Hopkins	.1518	.1507	— .0011	— .0006	[1].1405	.1400	— .0005	— .0003
	.1571	.1562	— .0009	— .0005	[1].1407	.1400	— .0007	— .0004
C. H. Jones	[3].1460	.1449	— .0011	— .0006	.1400	.1377	— .0023	— .0012
	[3].1460	.1446	— .0014	— .0008	.1400	.1394	— .0006	— .0003
	.1445	.1423	— .0022	— .0012				
	.1445	.1444	— .0001	— .0001				
F. S. Shiver	.1433	.1417	— .0016	— .0009	.1444	.1422	— .0022	— .0012
A. L. Winton	[3].1387	.1373	— .0014	— .0008				
	[3].1727	.1711	— .0016	— .0009				

[1] See Mr. Hopkins's notes.

[2] No blank determinations made, hence results not corrected.

[3] Direct evaporation, without previous separation of lime.

[4] Potassium chloride.

The figures in Table III are calculated from the analytical data of Table II. The weights of KCl taken are corrected for the moisture contained in the salt. This was not necessary in the case of the K_2SO_4 as the salt was anhydrous. The weights of KCl and K_2SO_4 found were obtained by deducting from the total K_2PtCl_6 that found in the reagents and impurities and multiplying by the commonly used factors 0.3056 for KCl and 0.357 for K_2SO_4. Mr. Cavanaugh failed to make blank determinations in a number of cases, and these results, not being corrected, are high.

It should be borne in mind that the quantities used in the case of the artificial German salts usually represent approximately 0.5 of the real salt, and therefore the errors given in grams in the table may be readily converted into percentage errors by moving the decimal point two places to the right and multiplying by two.

TABLE IV.—*Difference between* K_2O *taken and* K_2O *found, calculated by old and new factors—Average results of American chemists.*

[Difference given in milligrams.]

Method.	B. B. Ross.		F. B. Bomberger.		W. G. Brown.		G. W. Cavanaugh.		C. G. Hopkins.	
	Old factor.	New factor.	Old factor.	New factor.	Old factor.	New factor.	Old factor.	New factor.	Old factor.	New factor.
Direct evaporation, no $(NH_4)Cl$:										
Potassium chlorid c. p	......	......	......	......	—1.4	—0.3	......	......	......	......
Potassinm sulphate c. p	......	......	......	......	......	......	......	......	......	......
Lindo-Gladding method:										
Potassium chlorid c. p	......	......	—0.5	+0.2	—1.1	+0.2	......	......	......	......
Muriate of potash	—0.3	+0.2	—1.5	—0.2	—0.2	+1.0	......	......	—0.9	+0.2
Potassium sulphate c. p	......	......	—0.7	—0.1	—0.7	+0.7	......	......	......	......
Sulphate of potash, 90 per cent	......	......	—1.7	—0.8	—0.5	+0.6	—0.2	+0.9	—1.0	+0.1
Sulphate of potash and magnesia	......	......	—0.8	—0.1	—0.3	+0.4	......	......	—0.6	0.0
Kainit (lime not separated)	—0.4	0.0	......	......	—0.5	0.0	......	......	......	......
Kainit (lime separated)	......	......	—0.6	—0.3	—1.3	—0.9	—2.7	—2.3	—0.5	—0.1
Optional method:										
Potassium chlorid c. p	......	......	......	......	—2.9	—1.7	......	......	......	......
Muriate of potash	......	......	—1.8	—0.9	—2.8	—1.6	+0.1	+1.3	—2.0	—1.0
Potassium sulphate c. p	......	......	—0.8	—0.4	—5.2	—4.0	......	......	......	......
Sulphate of potash, 90 per cent	......	......	—0.7	—0.4	—5.8	—4.0	......	......	—3.6	—2.4
Sulphate of potash and magnesia	......	......	—1.2	—0.9	—3.9	—3.3	......	......	—0.8	—0.1
Kainit	......	......	—0.4	—0.1	—2.3	—1.7	......	......	—0.3	0.0

Method.	C. H. Jones.		F. S. Shiver.		A. L. Winton.		Average.	
	Old factor.	New factor.	Old factor.	New factor.	Old factor.	New factor.	Old factor.	New factor.
Direct evaporation, no $(NH_4)Cl$:								
Potassium chlorid c. p	....	....	—0.2	+0.2	—1.4	+0.2	—1.0	0.0
Potassium sulphate c. p	....	....	....	....	—0.6	+0.5	—0.6	+0.5
Lindo-Gladding method:								
Potassium chlorid c. p	—0.6	+0.7	....	....	....	....	—0.7	+0.4
Muriate of potash	—0.4	+0.6	—1.1	—0.1	—1.4	—0.3	—0.8	+0.2
Potassium sulphate c. p	—0.8	+0.4	....	....	....	....	—0.7	+0.3
Sulphate of potash, 90 per cent	—1.4	—0.3	....	....	—1.4	—0.3	—1.0	0.0
Sulphate of potash and magnesia	—0.4	+0.3	—1.2	—0.6	—1.0	—0.2	—0.7	0.0
Kainit (lime not separated)	—0.7	—0.3	....	....	—0.8	—0.4	—0.6	—0.2
Kainit (lime separated)	—0.6	—0.3	—0.9	—0.5	....	....	—1.1	0.0
Optional method:								
Potassium chlorid c. p	—2.5	—1.2	....	....	....	....	—2.7	—1.4
Muriate of potash	—1.0	+0.1	+0.5	+1.6	....	....	—1.1	—0.2
Potassium sulphate c. p	—2.9	—1.7	—0.3	+0.2	....	....	—2.3	—1.5
Sulphate of potash, 90 per cent	—3.0	—1.9	....	....	....	....	—3.3	—2.2
Sulphate of potash and magnesia	—2.4	—1.8	—2.9	—2.2	....	....	—2.2	—1.7
Kainit	—0.7	—0.4	—1.2	—0.8	....	....	—1.0	—0.6

Table IV shows the errors expressed in milligrams of K_2O, of the average results of each analyst calculated both by the old factors and by those based on revised atomic weights. It will be seen from Tables III and IV that as a rule considerable potash was lost in carrying out the optional method. This is due to an inherent defect of the process. It has long been known that barium sulphate carries down potash with it and the work of the past three years furnishes abundant illustration of this fact. The errors introduced, especially in the presence of sulphates, are so considerable as to render this method very inaccurate, and if it can not be so modified as to remedy this defect it should be stricken from our list.

It might be well to investigate, with regard to this point, the plan for precipitation followed by the Stassfurt chemists, namely, addition of barium chlorid, dropwise, to a strongly acid and boiling solution.

The results of the different analysts by the Lindo-Gladding method stand out in striking contrast to those by the optional method, being in nearly every case concordant, and, by the old factors, a trifle below theory. The slight minus errors, as will be discussed later, disappear almost entirely if the factors based on the universally accepted atomic weight of platinum be employed. Notwithstanding the criticisms of Breyer and Schweitzer, the Stassfurt chemists, Vogel and Haefcke, *the results of eight chemists working independently of each other in different laboratories and with different reagents, agree in establishing beyond a reasonable doubt, the remarkable accuracy of the Lindo-Gladding method.*

An experienced analyst who follows strictly the instructions and uses a Gooch crucible, should find it rapid, economical, and accurate.

It may be that the method has not given good results in the hands of European chemists, because the potassium platinichlorid has been filtered and weighed in some other way than on a Gooch crucible, which is universally employed in experiment stations and fertilizer control laboratories in this country.

If ammonium chlorid solution be poured through the double salt contained on an ordinary filter paper double decomposition may take place, the impurities may not be washed out thoroughly and the difficulty in removing the ammonium chlorid with alcohol may be encountered.

While the use of the Gooch crucible has been explicitly directed for the optional method, it should be specified also among the details for carrying out the Lindo-Gladding method.

It was used in obtaining all the results by American chemists given in the last three reports (except in a few cases otherwise noted) and undoubtedly in the work of preceding years.

Breyer and Schweitzer, and Vogel and Haefcke[1] claim that the removal of impurities from potassium platinichlorid is inadmissible, since thereby, through double decomposition, ammonium platinichlorid and potassium chlorid are formed, the former remaining as an impurity on the filter, the latter being carried into the filtrate. Fin Rener[2] first pointed out that this reaction takes place, but his results show that the change is very gradual. He found that a saturated solution of ammonium chlorid at 22° C., when in contact with finely divided potassium platinichlorid for one hour, decomposed but 0.27 per cent of the latter. Since our methods secure the double salt in a granular condition, which according to Fin Rener is not so rapidly acted on, and since operating with a Gooch crucible the ammonium chlorid solution is not in contact with the double salt longer than two or three minutes, errors from this source would not be expected to be and as our numerous results show are not appreciable.

There are few analytical methods where the precipitate is absolutely insoluble in the wash liquid, and it is absurd to discriminate against the Lindo-Gladding method for theoretical reasons which have no practicable significance.

It will be noticed that the results on kainit by direct evaporation with platinum solution are equally as good as when lime was previously separated. Calcium sulphate, when present in small quantities, is readily removed by ammonium chloride solution. We are indebted to De Roode[1] for calling attention to this fact; but, it should be remembered that *omission of previous separation of lime is merely returning to the plan first proposed by Gladding, from which many of us have never departed.*

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[1] Land. Versuchs-Stat. 47, 97.

[2] Pogg. Ann., 29, 637; Zeitschr. f. Anal. Chem., 6, 216.

FACTORS FOR THE CONVERSION OF POTASSIUM PLATINICHLORID TO POTASSIUM SULPHATE, CHLORID, AND OXID.

The factors which have been commonly used (0.3056 for converting K_2PtCl_6 to KCl, 0.3570 to K_2SO_4 and 0.19308 to K_2O), although based on old atomic weights, are those recommended by Fresenius (Ztschr. Anal. Chem., **21**, 238), who found in some experiments performed shortly after Seubert's determination of the now accepted atomic weight of platinum that these factors gave results nearer theory than those derived from the revised atomic weights. It has, however, been shown (J. Am. Chem. Soc., **17**, 453) that the method employed by Fresenius is at fault, yielding K_2PtCl_6 contaminated with included liquid, and for this reason the lower factors give the better results. The process adopted by this association at the last convention removes the above source of error, and the factors which are theoretically correct yield, practically, the best results. These are 0.1939 for conversion to K_2O, 0.3069 to KCl, and 0.3587 to K_2SO_4.

If the figures given with last year's report on potash are examined, it will be noticed that these new factors correct a tendency toward low results.

All the results of the present year have also been calculated by the new factors. In order to save space the figures are not given in detail, but only the difference between K_2O found and K_2O taken, the average being used when two or more determinations were made by the same analyst. (See Table IV.) Where blanks were not made the results, which for this reason could not be corrected, are not taken into account. A comparison of the figures in Table IV will show that the new factors give better results than the old. The errors occasioned in the optional method by loss of potash through occlusion are not, of course, overcome, but the Lindo-Gladding method has been shown to be practically free from such errors and the results using the new factors are very close indeed to theory.

The mere fact that the Lindo-Gladding method gives the most accurate results by the use of the revised factors is of itself an indication of the perfection of the process and the purity of the double salt obtained. It is only in the case of methods which yield an impure double salt that there is need of resorting to the unscientific procedure of retaining incorrect factors in order to compensate for errors of the method.

It should be stated that the investigation of the year was planned as a test of methods, not of analysts. Since those taking part in it with hardly an exception proved themselves competent to execute careful analyses, it was possible to carry out the original purpose and as a result we have been able to arrive at important conclusions.

Too often in the past inexperienced chemists have made the analyses and their results when published have been used as evidence against our methods.

It should be the purpose of the association to study and perfect methods, and reporters should be relieved from serving as a sort of examining board for testing the qualifications of chemists.

Results of German chemists.—The following translation of Dr. Tietjen's report was made by Dr. von Herff, of the office of the German Kali Works, New York, and is therefore authoritative:

LEOPOLDSHALL, *Stassfurt, July 3, 1896.*

For the purpose of testing the merits of the Lindo-Gladding method and the Stassfurt method for the determination of potash, comparative analyses were made in several laboratories of the potash works and also in the laboratory of the syndicate. These investigations were made with samples furnished by the agricultural

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[1] J. Am. Chem. Soc., 17, 85.

experiment station at New Haven, Conn., and the results obtained again show that the Lindo-Gladding method, in comparison with the Stassfurt method, is troublesome and not accurate. Satisfactory results were obtained only in the analysis of kainit.

In the laboratory of the salt mine, New Stassfurt, the following results were obtained:

A.—*Muriate of potash.*

I. Pure muriate of potash according to the Stassfurt method.

1. From 0.2 g. substance were obtained 0.6526 g. $2KCl.PtCl_4$. 2. From 0.2 g. substance were obtained 0.653 g. $2KCl.PtCl_4$. 3. From 0.2 g. substance were obtained 0.653 g. $2KCl.PtCl_4$.

Average, 0.6528; 99.75 per cent KCl.

II. Muriate of potash 80 per cent according to the Stassfurt method.

1. From 0.2 g. muriate of potash=0.419 g. 100 per cent KCl+.25 cc impurities were obtained 1.3745 $2KCl.PtCl_4$; calculated, 83.8 per cent; found, 84 per cent KCl. 2. From 0.423 g. muriate of potash=0.422 g. 100 per cent KCl+.25 cc impurities were obtained 1.383 g. $2KCl.PtCl_4$; calculated, 84.4 per cent; found, 84.53 per cent. 3. From 0.42 g. muriate of potash=0.419 g. 100 per cent KCl 25 cc impurities were obtained 1.368 g. $2KCl.PtCl_4$; calculated, 83.8 per cent; found, 83.61 per cent.

Sample No. 3 was washed with alcohol, as prescribed in the Lindo-Gladding method, I.

III. Pure muriate of potash according to the Lindo-Gladding method, I.

1. From 0.5 g. muriate of potash were obtained 1.625 g. $2KCl.PtCl_4$=99.32 per cent. 2. From 0.5 g. muriate of potash were obtained 1.6193 g. $2KCl.PtCl_4$ =99 per cent. 3. From 0.5 g. muriate of potash were obtained 1.621 g. $2KCl.PtCl_4$=99.1 per cent.

IV. Muriate of potash 80 per cent according to the Lindo-Gladding method, I.

1. From 0.42 g. muriate of potash 0.419 g. 100 per cent KCl+25 cc impurities were obtained 1.3665 g. $2KCl.PtCl_4$; calculated KCl 83.8 per cent; found, 83.82 per cent. 2. From 0.421 g. muriate of potash 0.420 g. 100 per cent KCl+25 cc impurities were obtained 1.3673 g. $2KCl.PtCl_4$; calculated, 84.0 per cent; found, 83.57 per cent. 3. From 0.426 g. muriate of potash 0.425 g. 100 per cent KCl+25 cc impurities were obtained 1.384 g. $2KCl.PtCl_4$; calculated, 85.0 per cent; found, 84.59 per cent.

B.—*Sulphate of potash.*

I. Pure sulphate of potash according to the Stassfurt method.

1. From 0.2 g. sulphate of potash were obtained 0.5597 g. $2KCl.PtCl_4$=99.7 +0.3=100 per cent K_2SO_4. 2. From 0.2 g. sulphate of potash were obtained 0.5604 g. $2KCl.PtCl_4$=99.8+0.3=100.1 per cent K_2SO_4.

II. Sulphate of potash 90 per cent according to the Stassfurt method. 1.84 g. of pure sulphate of potash+100 cc impurities at 200 cc, of which 20 cc were evaporated.

1. From 0 2 g. substance were obtained 0.5129 g. $2KCl.PtCl$; calculated, 92 per cent, K_2SO_4; found, 91.45+0.3=91.75 per cent. 2. From 0.2 g. substance were obtained 0.5134 g. $2KCl.PtCl$; found, 91.54+0.3=91.84 per cent.

III. Pure sulphate of potash according to the Lindo-Gladding method, I.

1. From 0.5 g. sulphate of potash were obtained 1.4191 g. $2KCl.PtCl_4$=101.2 per cent K_2SO_4. 2. From 0.5 g. sulphate of potash were obtained 1.4188 g. $2KCl.PtCl_4$=101.18 per cent K_2SO_4. 3. From 0.5 g. sulphate of potash were obtained 1.407 g. $2KCl.PtCl_4$=100.35 per cent K_2SO_4.

IV. Sulphate of potash 90 per cent according to Lindo-Gladding method, I.

1. From 0.461 g. sulphate of potash+25 cc impurities were obtained 1.3056 g. $2KCl.PtCl_4$; calculated K_2SO_4, 92.2 per cent; found, 93.11 per cent. 2. From 0.46 g. sulphate of potash+25 cc impurities were obtained 1.2921 g. $2KCl.PtCl_4$; calculated, K_2SO_4, 92.4 per cent; found, 92.15 per cent. 3. From 0.46 g. sulphate of potash+25 cc impurities were obtained 1.3035 g. $2KCl.PtCl_4$; calculated. K_2SO_4, 92 per cent; found, 92.96 per cent.

V. Pure sulphate of potash according to Lindo-Gladding method, II.

1. From 0.5 g. sulphate of potash were obtained 1.360 g. $2KCl.PtCl_4$=97 per cent K_2SO_4. 2. From 0.5 g. sulphate of potash were obtained 1.3784 g. $2KCl.PtCl_4$=98.3 per cent K_2SO_4. 3. From 0.5 g. sulphate of potash were obtained 1.3775 g. $2KCl.PtCl_4$=98.2 per cent K_2SO_4. 4. From 0.5 g. sulphate of potash were obtained 1.369 g. $2KCl.PtCl_4$=97.64 per cent K_2SO_4. 5. From 0.5 g. sulphate of potash were obtained 1.374 g. $2KCl.PtCl_4$=98 per cent K_2SO_4.

C.—*Sulphate of potash-magnesia.*

I. According to the Stassfurt method, 1.04 g. pure sulphate of potash + 100 cc impurities at 200 cc, of which 20 cc were evaporated.

1. From 0.2 g. substance were obtained 0.2916 g. $2KClPtCl_4$; calculated, K_2SO_4, 52 per cent; found, 51.99 per cent. 2. From 0.2 g. substance were obtained 0.2908 g. $2KClPtCl^4$; found, 51.85 per cent.

II. According to Lindo-Gladding method, I.

1. From 0.262 g. sulphate of potash + 25 cc impurities were obtained 0.7507 g. $2KClPtCl_4$; calculated, 52.4 per cent; found, 53.54 per cent. 2. From 0.260 g. sulphate of potash + 25 cc impurities were obtained 0.7372 g. $2KClPtCl_4$; calculated, 52 per cent; found, 52.58 per cent. 3. From 0.261 g. sulphate of potash + 25 cc impurities were obtained 0.7322 g. $2KClPtCl_4$; calculated, 52.2 per cent; found, 52.2 per cent.

D.—*Kainit.*

I. According to the Stassfurt method, 0.7 g. pure sulphate of potash + 125 cc impurities at 250, of which 20 cc were evaporated.

1. From 0.2 g. substance were obtained 0.1565 g. $2KClPtCl_4$; calculated, K_2SO_4, 28 per cent; found, 27.9 per cent. 2. From 0.2 g. substance were obtained 0.1573 g. 2KClPtCl; found, 28.1 per cent.

II. According to the Lindo-Gladding method, I, without removal of lime.

1. From 0.1444 g. sulphate of potash + 25 cc impurities were obtained 0.4084 g. $2KClPtCl_4$; calculated, 28.88 per cent; found, 29.16 per cent K_2SO_4. 2. From 0.140 g. sulphate of potash + 25 cc impurities were obtained 0.3908 g. $2KClPtCl_4$; calculated, 28 per cent; found, 27.9 per cent K_2SO_4. 3. From 0.140 g. sulphate of potash + 25 cc impurities were obtained 0.3960 g. $2KClPtCl_4$; calculated, 28 per cent; found, 28.25 per cent K_2SO_4.

The results reported by the Consolidated Alkali Works at Westeregeln have reference only to kainit. An artificial kainit was produced by means of pure substances furnished by Mr. Winton. This contained in 50 g. 12.540 g. K_2SO_4, therefore 25.08 per cent.

In the analysis of this kainit the following results were obtained by the Stassfurt method: From 0.4 g. substance were obtained 0.2810 $K_2PtCl_4 = 25.08$ per cent K_2SO_4.

With the Lindo-Gladding method the following results were obtained: (*a*) With preceding precipitation of lime, from 0.5 g. substance were obtained 0.3535, 0.3575 $K_2PtCl_6 = 25.22$ per cent, 25.52 per cent K_2SO_4. (*b*) Lime not precipitated, from 0.5 g. substance were obtained 0.3575 $K_2PtCl_6 = 25.52$ per cent K_2SO_4.

From the laboratory of the syndicate the following results were obtained:

A. 0.3056 pure muriate of potash, free from water, mixed with impurities corresponding to the 80 per cent muriate of potash.

1. According to the Stassfurt method, 1.000, 1.001, 1.000 K_2PtCl_6. 2. According to the Lindo-Gladding method, 0.991, 0.993 K_2PtCl_6.

B. 0.357 pure sulphate of potash, free from water, mixed with impurities corresponding to the 90 per cent sulphate of potash.

1. According to the Stassfurt method, 0.995 g., 0.995, 0.996 K_2PtCl_6. 2. According to the Lindo-Gladding method, 1.013 g., 1,012 K_2PtCl_6.

C. 0.2 g. pure sulphate of potash, mixed with impurities corresponding to the potash-magnesia.

1. According to Stassfurt method, 0.557 K_2PtCl_6, 0.1988 K_2SO_4, 0.559 $K_2PtCl_6 = 0.1996$ K^2SO_4. 2. According to Lindo-Gladding method, 0.5686 $K_2PtCl_6 = 0.2030$ K^2SO_4.

D. 0.2 g. pure sulphate of potash, mixed with impurities corresponding to the kainit.

1. According to the Stassfurt method, 0.560, 0.561 $K_2PtCl_6 = 0.200$, 0.2003 K_2SO_4. 2. According to the Lindo-Gladding method, 0.562, 0.561 $K_2PtCl_6 = 0.2006$, 0.2003 K_2SO_4.

DR. TIETJENS,
For the Sworn Chemists of the Sales-Syndicate of the Potash Works.

TABLE V.—*Average results from German chemists connected with the Stassfurt industry.*

[Old factors.]

	Stassfurt method.				Lindo-Gladding method.			
	KCl or K_2SO_4 taken.	KCl or K_2SO_4 found.	KCl or K_2SO_4 error.	K_2O error.	KCl or K_2SO_4 taken.	KCl or K_2SO_4 found.	KCl or K_2SO_4 error.	K_2O error.
Potassium chlorid, c. p.:	*Gram.*	*Gram.*	*Gram.*	*Gram.*	*Gram.*	*Gram.*	*Gram.*	*Gram.*
Neu-Stassfurt	0.1991	0.1995	+0.0004	+0.0002	0.4977	0.4956	—0.0021	—0.0013
Syndicate Laboratory	.3056	.3057	+ .0001	+ .0001	.3056	.3032	— .0024	— .0015
Muriate of potash, 80 per cent:								
Neu-Stassfurt	.4191	.4202	+ .0011	+ .0006	.4204	.4195	— .0009	— .0005
Potassium sulphate, c. p.:								
Neu-Stassfurt	.2000	.2005	+ .0005	+ .0003	.5000	.5052	+ .0052	+ .0028
Sulphate of potash, 90 per cent:								
Neu-Stassfurt	.1840	.1838	— .0002	— .0001	.4603	.4642	+ .0039	+ .0021
Syndicate Laboratory	.3570	.3564	— .0006	— .0003	.3570	.3615	+ .0045	+ .0024
Sulphate of potash and magnesia:								
Neu-Stassfurt	.1040	.1039	— .0001	— .0001	.2610	.2642	+ .0032	+ .0017
Syndicate Laboratory	.2000	.1992	— .0008	— .0004	.2000	.2030	+ .0030	+ .0016
Kainit:								
Neu Stassfurt	.0560	.0560	.0000	.0000	[1].1415	.1422	+ .0007	+ .0004
Westeregeln	.1003	.1003	.0000	.0000	[2].1254	.1269	+ .0015	+ .0008
	....	....	....	....	[1].1254	.1276	+ .0022	+ .0014
Syndicate Laboratory	.2000	.2001	+ .0001	+ .0001	[2].2000	·2004	+ .0004	+ .0002
Potassium sulphate, c. p., optional method:								
Neu-Stassfurt	....	....	....	....	.5000	.4897	— .0103	— .0056

[1] Lime not precipitated.

[2] Lime precipitated.

In Table V are given the average figures obtained in each of the three laboratories, calculated by the old factors, from which it appears that while the German chemists obtained very accurate results by their own method, they had, as a rule, poor success with ours.

The Lindo-Gladding method gave low results on potassium chlorid, with and without addition of impurities, while on the sulphate containing salts they were, as a rule, very much too high.

At Neu-Stassfurt seven determinations were made by the optional method on pure potassium sulphate, with an average loss of 0.0103 gram.

In view of the accurate results which were obtained by the Lindo-Gladding method in eight American laboratories, it seems probable that the German chemists carried out the details of the process differently. Possibly they did not use the Gooch crucible, which in our laboratories is identified with the method.

AMENDED AND ADOPTED REPORT OF THE COMMITTEE OF RECOMMENDATIONS IN RELATION TO POTASH.

(1) That the following be used as factors in computing potash results instead of those now in use: Factors for KCl=.3069; factors for K_2SO_4=.3587; factors for K_2O=.1939.

(2) That a careful test of the accuracy of the Stassfurt method be made by the next reporter by the use of pure potash salt in conjunction with impurities corresponding to those found in the potash salts.

(3) That the next reporter have a careful test made of the accuracy of the optional method, by acidulating the solution before precipitating the sulphuric acid.

(4) That the following resolution be adopted: *Resolved*, That it is the sense of this

association that in mixed fertilizers chlorin should be taken into consideration in reporting upon their composition.

(5) That the reporter for 1897 be requested to test the accuracy of kainit determinations by the Lindo-Gladding method without previous removal of lime and sulphuric acid.

(6) That page 22 (2) (b) be changed to read as follows: When it is desired to determine the total amount of potash in organic substances, like cotton-seed meal, etc.

(7) That Mr. Winton be authorized to revise the phraseology of the description of the potash methods.

H. J. WHEELER,
For Committee on Recommendations of Reporters.

Convention adjourned until 1.30 p. m.

FRIDAY—AFTERNOON SESSION.

The president called for papers on the subject of the determination of potash in fertilizers.

Mr. CURTIS. I desire to present a paper by Mr. Scovell, Mr. Peter, and myself, entitled "Some sources of error in the determination of potash in fertilizers."

The PRESIDENT. Before the presentation of the paper we will hear the report of the committee appointed to invite the Secretary and Assistant Secretary of Agriculture to attend our meetings.

Messrs. Frear and Lindsey, the committee appointed to wait upon the Secretary of Agriculture, reported that the Secretary was unable to attend, owing to his being present at the Cabinet meeting. The Assistant Secretary has promised to be present at some time during the meetings of the association.

ON SOME SOURCES OF ERROR IN THE DETERMINATION OF POTASH IN FERTILIZERS.

By M. A. SCOVELL, A. M. PETER, and H. E. CURTIS.

The investigation described in this paper was occasioned by the appearance of certain small but annoying and seemingly unaccountable discrepancies, in the case of certain fertilizers, between the potash determinations made by two of the chemists of this laboratory when working on the same samples and with the same apparatus and reagents. For instance, in a fertilizer composed of acid phosphate, tankage, dried blood, and muriate of potash (No. 3345), one chemist obtained 1.68 and 1.71 per cent potash, while the other obtained 1.80 and 1.80 per cent; in another similar fertilizer (No. 3346) one obtained 1.76 and 1.83, while the other obtained 1.92 and 1.96. Upon carefully comparing their manipulation in carrying out the official Lindo-Gladding method, the only difference found was that the one who usually obtained the lowest results, always measured the 300 cc of water with which the substance was to be boiled, while the other was in the habit of pouring upon the substance as much water as he judged to be not less than 300 cc, and probably exceeded that amount in nearly every case. The further observation that the differencesdid not appear when both chemists worked on the same solution, but only when each prepared a separate solution of the fertilizer for analysis confirmed the belief that the cause was to be sought in some difference of manipulation in preparing the solution. One of us (Curtis) suggested the theory that the spongy material, such as tankage, etc., in the fertilizer, having become saturated with the solution containing potash during the boiling, retains this solution in its original concentration when the liquid is made up to volume and filtered. If, then, the fertilizer be boiled with, say, 400 cc of water, the solution retained will be weaker and the final result will be higher than where only 300 cc were used, assuming evaporation to be about the same in each case. On the other hand, supposing the same quantity of water taken in each case, if the boiling be brisk and the evaporation rapid the solution will be more concentrated than if it were slow; the solution retained will be stronger and the final result lower. The following results seem to point to the correctness of this theory:

Method.	3346.	3040.	3042.	3347.	3404.	3407.	Tankage mixture.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
K_2O, L. G. method, boiling with 300 cc water.	1.85 1.82	2.51	1.66	2.48	1.63	2.34	4.95
Same, boiling with 400 to 450 cc water.	1.93 1.97	2.57	1.71	2.71	1.61	2.42	5.02
Gain	.115	.06	.05	.25	.02	.08	.07

In the series where 300 cc of water were used the boiling was purposely brisk and the evaporation amounted 40 or 50 cc in each case; in the other series the boiling was slow and evaporation very little. In the first series the residue at the end of the boiling would be saturated with a solution containing the potash in about 250 cc of liquid, while in the second the same amount of potash would be contained in more than 400 cc. The fertilizer 3346 was composed of acid phosphate, tankage, dried blood, and muriate of potash; 3040 and 3042 contained acid phosphate and cotton-seed meal; 3347 was an acid phosphate containing no organic matter with muriate of potash; 3404 contained tankage and dried blood, and only showed 3 per cent water soluble phosphoric acid; 3407 was an acid phosphate with potash, but no organic material, and the last was a mixture of tankage, acid phosphate, and muriate of potash. It will be noted that the difference is greater in the case of the plain acid phosphates than in the others, where organic materials were present.

To further test the theory of occlusion by porous materials some experiments were made by pouring a solution of potash salt of known strength upon filter paper or chamois skin in a 500 cc flask, and after standing a short time, making up to volume, filtering, and determining the potash in 500 cc of the filtrate, as in the regular course of analysis. The results are stated as platinum salt obtained, and also as per cent of potash, calculated as if obtained from 1 gram of fertilizer.

The potash solution used contained 0.05 gram c. p. KCl in 50 cc.

Materials and time.	K_2PtCl_6 obtained (gram).	Per cent K_2O.
50 cc KCl solution alone	0.1608 .1612	3.11
50 cc K Cl and 10 grams filter paper. After 1 hour it was made up to volume, shaken well, and filtered.	.1366 .1353	2.62
50 cc KCl and 6 grams chamois skin, cut fine, instead of paper	.1403 .1399	2.71
50 cc KCl and 250 cc water with 5 grams filter paper. Stood one-half hour before making up to volume	.1598	3.08
50 cc KCl in same way, but stood 36 hours after making up to volume before filtering	.1590	3.08
50 cc KCl in same way as the next preceding, but used 9 grams paper	.1588	2.90

The effect of occlusion of the solution in the porous material appears very distinctly in the first two experiments in which KCl was used in less dilute solution than in the others.

To determine whether a precipitate of phosphates acts in the same way, 10 grams of precipitated tricalcium phosphate were boiled one-half hour with 10 cc dilute sulphuric acid, a known quantity of the KCl solution, and enough water to make about 300 cc. Ammonia and ammonium oxalate were then added, the volume was made up to 503.5 cc, allowing 3½ cc for volume of precipitate, and the determination finished as in the regular analysis. The results are stated as platinum salt obtained from 50 cc of filtrate and also as percentage of K_2O calculated as from 1 gram. The weight of platinum salt has been diminished by 0.0009, the amount obtained in a blank experiment with the precipitated phosphate.

Quantities used.	K_2PtCl_6 (gram).	Per cent K_2O.
50 cc KCl solution, alone (from previous experiment)........................	0.1608 .1617	3.11
50 cc KCl, 10 grams tricalcium phosphate, etc., stood over night after adding the ammonia and ammonium oxalate and before making up to volume.	.1544 .1525	2.96
Deficit..	.0078	.15
100 cc KCl solution, alone (from previous experiment)........................	.3225	6.22
100 cc KCl, 10 grams tricalcic phosphate as before........................	.3118 .3124	6.02
Deficit..	.0104	.20

It thus appears that the precipitated phosphates retain a notable amount of potash, and this in a more marked degree than the organic materials experimented upon. The foregoing results seem to indicate that the absolute error in analysis due to retention of potash by the phosphates is quite noteworthy. It is true that in making up the solution to 500 cc, without allowing for the volume occupied by the fertilizer, we introduce an error in the opposite direction, but as 10 grams of fertilizer do not occupy more than about 4 cc it is evident that this compensation may not always be sufficient. We see also in this source of error a reason why the "alternate" method should give slightly higher results, as a rule, than the Lindo-Gladding.

POTASSIUM (MONO) METAPHOSPHATE.

In the experiments with tricalcium phosphate just described the first series of determinations made gave a very remarkable result, the figures obtained being 2.57, 1.35, 0.50, 1.78, 2.77, and 1.94 per cent K_2O, the theoretical amount being 3.11 per cent. It was noticed that the porcelain dishes in which the residues had been ignited for the expulsion of ammonia salts were much corroded, and on adding water with a few drops of hydrochloric acid to the ignited residue it was found that a quantity of white substance in the form of glassy scales remained undissolved. This was supposed to be silica and was filtered out before adding platinic chlorid. As soon as it appeared that there had been a serious loss of potash somewhere, this white substance was examined more carefully and was found to contain the insoluble modification of potassium metaphosphate (mono-metaphosphate) as well as silica, etc., from the porcelain. The solution for analysis prepared as described with tricalcic phosphate contained ammonium phosphate. On evaporation and ignition there remained an excess of phosphoric acid, and the potash was, of course, converted into (mono) metaphosphate. This substance is almost insoluble in pure water, but dissolves in a short time when digested on the water bath with water acidified with hydrochloric acid. We committed the error of assuming that because nothing but a potash salt was present it would dissolve readily in hot water and did not allow time enough for the solution of the metaphosphate in the dilute acid.

Of course the filters were thoroughly washed with hot water, but this simply removed the acid liquid without affecting the solution of the metaphosphate.

Potassium (mono) metaphosphate was prepared and analyzed by Maddrell (Liebig's Annalen, LXI, p. 53), and is formed when potassium chlorid or other potash salt is heated with excess of phosphoric acid. We prepared some of the pure salt and found it to be almost insoluble in cold water and very slowly soluble in boiling water with conversion into orthophosphate. An experiment with cold water gave its solubility as about 1 part in 5,000. The solubility in boiling water depended on the length of time of boiling. The finely powdered salt dissolved easily in warm dilute acids, even in acetic acid. It appeared to be not sensibly volatile on ignition to a bright red heat, but lost weight on ignition with a blast lamp.

The frequent presence of soluble phosphates in the solutions of fertilizers prepared by the Lindo-Gladding method has been pointed out by Huston and a remedy suggested. Their presence is objectionable on account of the action of the phosphoric acid on the dishes in which the residue is ignited. If these dishes are of porcelain, a quantity of finely divided silica is frequently obtained in the platinum precipitate, rendering it slow of filtration. Besides this it appears from our experience that a loss of potash is sometimes possible if sufficient attention is not paid to dissolving the ignited residue with water and hydrochloric acid. In the analysis of fertilizers it frequently happens that there is a slight residue which will not dissolve even after protracted digestion, but we should always allow time enough to insure complete solution of the potash compounds.

KENTUCKY AGRICULTURAL EXPERIMENT STATION,
Lexington, Ky., November 6, 1896.

After the reading of the recommendations the president called for a discussion of the paper.

Mr. Wiley moved that on account of the importance of bringing American and European methods for estimating potash into harmony and for the purpose of pointing out some mistakes in the attacks which have been made on the method followed in this country, Messrs. Winton and Wheeler be requested to prepare a paper on the official Lindo-Gladding method for estimating potash for publication in the Versuchsstationen.

The PRESIDENT. I think it is very appropriate to take some such action as this.

The motion was adopted.

Mr. SHUTT. I should like to inquire if the determination of potash in soils should properly be exhibited now or come up later, when the report on soils is read.

The PRESIDENT. It is better, I think, to discuss that subject when the report on soil analysis is under consideration. If there is no further discussion of the subject, the recommendations of the reporter on potash will be referred to the committee, in harmony with the usual order. Perhaps we had better take up now the next subject, viz, phosphoric acid.

Mr. McDONNELL. I would like to have the report on phosphoric acid deferred until to-morrow.

It was voted that the phosphoric acid report be deferred, and that the report on soils take its place.

Mr. PATTERSON. It seems to me, Mr. President, that we should not defer reports because of the absence of certain members of the association who desire to hear them. The order of business should be arranged for the benefit of those who are present, and not for those who are absent.

Mr. GOSS. It was not expected, Mr. President, that the report on soils should come up at the present time, and hence it is not fair to those who are absent to have it brought forward now, when the regular order of business calls for something else.

The PRESIDENT. It seems advisable in the circumstances to let the report on soils go over. I would like to ask if Mr. Lindsey is ready to report on foods and feeding stuffs?

Mr. LINDSEY. I think now is perhaps as good a time as any to present my report, as I suppose there are very few in the association who are interested in it any way.*

The PRESIDENT. Mr. Lindsey will then present his report on foods and feeding stuffs.

REPORT ON ANALYSIS OF CATTLE FEEDS.

By J. B. LINDSEY.

Your reporter for the present year has not considered it wise to attempt any further comparison of results obtained by different analysts in determinations of moisture, crude ash, fiber, fat, and protein. He believes these methods to be as perfect as they ever can be made, and when carried out by experienced chemists will give at least comparative results. It is generally recognized that these terms do not refer to single substances, but rather to groups of ingredients possessing similar characteristics.

For example, investigation has shown that crude fiber prepared from coarse fodders, brans, and the like, usually consists principally of dextroso-cellulose, combined with the small quantities of lignin or lignin acids not removed by the action of dilute acid and alkali. It also contains more or less pentosans, so closely identified with the dextroso-cellulose and lignin, as to be considered a pentoso-cellulose. If one, therefore, desires to continue investigations along this line, the aim should be to secure a method for the determination of cellulose separated from other ingredients. That this is at present surrounded with difficulty is clear, from the fact that as yet we have not a very exact knowledge of the several modifications of cellulose.

Again, it is known that ether extract comprises not only the true fats, but also the resins, waxes, coloring matter, cholesterin, and lecithin. If one would study this class of substances, the aim should be to perfect methods to estimate them separately. No single method, no matter how much we may compare individual results, will do this.

The admirable work of Osborne at the Connecticut Experiment Station is throwing much additional light upon the meaning of crude protein. We must be content with the collective estimation of albuminoids and nonalbuminoid nitrogen-containing bodies until investigators have thoroughly studied the many different forms of protein that exist in plants and seeds.

The term "nitrogen-free extract" has had until recently a very doubtful meaning. It has been said to consist of starch, sugar, gums, etc. It included everything known and unknown that could not be classified elsewhere. Thanks to the investigation of Tollens,[1] Schulze,[2] and their pupils, a great deal of light has been thrown upon this hitherto questionable combination. In addition to starch and the small quantities of ready formed sugars of the plant, it has been found to contain the larger part of the lignin, removed from combination with the cellulose by the action of the acid and alkali, and a group of bodies called hemicelluloses, which are distinguished from the true cellulose by their solubility in dilute mineral acids and in F. Schulze's reagent, and by their insolubility in Schweizer's reagent. The hemicelluloses include xylan and araban or pentosans, dextran laevulan, mannan and galactan, which, when hydrolyzed with dilute acid, yield the sugars xylose, arabinose, dextrose, laevulose, mannose, and galactose. Investigations have shown the pentosans to be by far the most generally distributed, followed next by galactan.

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[1] Landw. Vers. Sta., 39, p. 401, and Journal für Landw., 1896.

[2] Zeitsch für Physiol. Chem. Bds., 14-16.

From these few remarks it will be seen that future work on cattle feeds ought to a considerable extent to be in the line of direct investigation. One must identify and study the nature of the substances composing plants before attempting to estimate them quantitatively.

Your reporter for this year felt that it would not be wise to undertake too great a variety of work, but rather to concentrate upon one or two special lines. It seemed wise to continue the work marked out by Mr. Patterson a year ago and test methods that have been proposed for the estimation of individual substances comprising the extract matter. Invitations were accordingly sent out early in November, 1895, to as many as it seemed would be interested in the work. Fifteen replies were received, to which samples and instructions were duly sent.

Three of this number have failed to send results or any excuse. Seven during the month of October have stated their inability from one cause and another to carry out the work, so that we have actual results from but six chemists, including our own station.

The lines of work proposed were as follows:

A. *Estimation of starch by three distinct methods:*

I. Sachsse's method.
II. Diastase method.
III. Märcker's method.

B. *Estimation of pentosans using method perfected by Mann, Flint, and Tollens.*

C. *Estimation of galactan by method of Rischbieth, Credyt, Hadecke, and Tollens.*

A.—STARCH.

Two samples were sent out—(I) potatoes and (II) Buffalo gluten feed. This latter consists of hull, germ, and gluten of Indian corn. The samples were both finely ground so as to pass through a 12-mm. mesh sieve.

I.—SACHSSE'S METHOD.

Extract 4 to 5 grams of the substance with ether, then treat the residue in a beaker with 50 cc of 10 per cent alcohol for half an hour with constant stirring, filter and wash with strong alcohol. Bring the residue with 200 cc of water and 20 cc of 25 per cent hydrochloric acid (sp. gr. 1.125) into a 10-ounce flask provided with a reflux condenser and heat in a boiling-water bath for three hours, cool and very nearly neutralize with sodium carbonate (avoiding excess). Clarify if necessary with 10 cc basic acetate of lead and make up to 500 cc. Pour off through a dry filter and determine the dextrose in an aliquot part by Allihn's method. Convert the weight of the dextrose to that of starch by the factor 0.9.

II.—DIASTASE METHOD.

Free 3 to 5 grams of the substance from fat and water soluble carbohydrates, as under Sachsse's method. Bring the residue into a beaker with 50 cc of water, and immerse in a boiling-water bath, stirring constantly until the starch forms a paste. Cool to 65° C. and add 25 cc of malt extract, and maintain at this temperature until the solution no longer gives the starch reaction with iodin. Filter into a 10-ounce flask and wash until the filtrate amounts to 200 cc. Then add 20 cc of 25 per cent hydrochloric acid (sp. gr. 1.125), connect with a reflux condenser, and proceed as under Sachsse's method.

III.—MÄRCKER'S METHOD.

Extract from 3 to 5 grams of the substance with ether to remove fat and then bring the substance into a beaker with 50 cc of 10 per cent alcohol and allow to stand for half an hour with frequent stirring. Filter, wash with alcohol, and allow to dry. Remove dry substance from filter, make fine, and bring into a Linter pressure bottle (if Soxhlet digestor be not at hand), add 50 cc of water, and immerse bottle in boiling water till starch is all brought into a jelly (stirring frequently). Cool to 65° C., add 10 cc malt extract, and digest at 65° C. for one hour. Now add 5 cc of a 1 per cent tartaric acid solution and heat at 140° C. for one-half hour, or 110° C. for one hour. Cool to 65° C., add 10 cc malt extract, and maintain at this temperature until solution no longer gives starch reaction with iodin; then filter into a 10-ounce flask, wash until the filtrate measures 200 cc., add 20 cc HCl of 1.125 sp. gr., and heat the flask, to which is fitted a reflux condenser, in a boiling-water bath for two and one-half hours. Neutralize with Na_2CO_3, filter if necessary, and make up to 500 cc Determine dextrose as in Allihn's method.

Prepare the malt extract by digesting 10 grams of fresh, finely ground malt over night, at ordinary room temperature, with about 175 cc of water, filter, and make to 200 cc. Determine the amount of dextrose in a given quantity by treating it the same as with the determination of starch.

Starch determinations.

	I. Potatoes.			II. Buffalo gluten feed.		
	Sachsse's method.	Diastase method.	Märcker's method.	Sachsse's method.	Diastase method.	Märcker's method.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
United States Department of Agriculture, W. H. Krug	....	62.69	....	....	21.90	19.84
Wisconsin Experiment Station F. W. Woll	68.23	....	....	39.91	19.56	....
Vermont Experiment Station, C. H. Jones	68.40	63.32	61.90	38.53	21.54	21.00
New Hampshire Experiment Station, C. D. Howard	70.41	64.19	....	38.70	21.14	....
Columbia University, H. C. Sherman	77.48	67.15	68.00	42.37	22.71	23.36
Massachusetts Experiment Station, E. B. Holland	69.80	66.73	69.15	38.60	20.85	25.27
Average	69.21	64.82	68.57	38.93	21.29	22.37

The results are so few that one can draw no very accurate conclusions. On potatoes, the figures obtained by Woll, Jones, Howard, and Holland with Sachsse's method agree quite well and represent the amount of starch usually found. Sherman's results are without doubt too high. With the diastase method on the same substance, Sherman and Holland obtain practically identical results. In case of Märcker's method, Sherman and Holland again agree, and both seem to have secured higher results than with the diastase method. With the potatoes, Sachsse's method appears to give slightly higher results than either of the others.

Coming to the estimation of starch in the gluten feed, marked differences are noted. Sachsse's method shows some variations, but not extreme ones. For some reason Sherman secures a higher amount of starch by this method in case of both samples. Both the diastase and Märcker methods agree fairly well, but show very much lower results than those obtained by Sachsse's method. This is to be expected, for the gluten feed contains 16 or more per cent of pentosans, which substance, as well as all hemi-celluloses, is converted into sugars by the action of dilute acids. The fact is firmly established that Sachsse's method is entirely unreliable for the determination of starch in all cases where any of the hemi-celluloses are present. Recent investigations limit its value.

Märcker's method as a rule gives results slightly higher than the diastase method. This may be possibly due to the action of pressure on carbohydrate bodies other than starch.

I desire in this connection to present the results of Mr. H. C. Sherman, recently published.[1]

	Sachsse's method.	Diastase method.	Märcker's method.
	Per cent.	*Per cent.*	*Per cent.*
Pure starch	82.30	82.49	82.39
Wheat flour	68.35	66.55	67.15
Oatmeal	59.01	56.23	56.16
Graham flour	58.63	55.32	....
Wheat bran	38.82	20.97	21.09
Wheat straw	22.69	4.39	4.80
Corn fodder	20.13	.96	....

The above figures confirm the results previously given.

OBJECTIONS TO THE DIASTASE AND MÄRCKER METHODS.

First. We are not positive that the diastase has no solvent action upon the hemi-celluloses. Stone's work would indicate, however, that the pentosans are not attacked, and it is probable that the action, if any, is slight.

Second. The inconvenience of being obliged to prepare frequent malt solutions, and of estimating the amount of reducing sugar they contain.

Third. The additional inconvenience, should Märcker's method be employed, of heating under pressure.

It is to be hoped that some method will be devised in the near future that will do away with these difficulties.

Your reporter feels justified in recommending as provisional methods for the estimation of starch the so-called diastase and Märcker methods. The Sachsse's method is entirely out of the question.

If conveniences are at hand for working the Märcker method, it should have the preference.

B. ESTIMATION OF PENTOSANS.

In view of the very general occurence of the pentosans in plants and seeds, it seemed advisable to familiarize chemists with the method employed in their quantitative estimation and to see if closely agreeing results could be obtained with the method in the hands of different analysts.

The method is the one worked out by Flint, De Chalmot, and Tollens and is described as follows:

Weigh out 3 to 5 grams (depending on the amount of pentosans present) of the finely ground material, and transfer to a 300 cc flask. After adding 100 cc of hydrochloric acid of 1.06 sp. gr., connect with a Liebig condenser, and distil 30 cc, taking ten to fifteen minutes for the distillation. Instead of putting the flask in Rose's metal to diffuse the heat, as Flint and others suggest, we have placed it upon a piece of gauze with equally satisfactory results. Now add 30 cc more acid by means of a separatory funnel (the stem of which passes through the cork into the flask), and so continue the process until a drop of the distillate gives no red coloration on filter paper that has been moistened with anilin acetate (a few drops of anilin in a little 50 per cent acetic acid). Ten to eleven distillations are generally sufficient. Flint has shown that for constant results the presence of a certain amount of salt in a definite quantity of solution is essential. Furfurol hydrazon is more insoluble with 81 grams of sodium chlorid in 400 cc of distillate than when less is present, and these proportions should be always used. Add to the obtained distillate, brought into a 700 to 800 cc beaker, the necessary amount of salt and water to raise it to this standard (see table following).

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[1] School of Mines Quarterly, Vol. XVII, No. 4.

Distillate (cubic centimeters).	Water (cubic centimeters).	Salt to be added (grams).	Distillate (cubic centimeters).	Water (cubic centimeters).	Salt to be added (grams).
400	....	....	150	250	50.75
350	50	10.15	100	300	60.90
300	100	20.30	50	350	71.05
250	150	30.45	....	400	81.20
200	200	40.60			

Neutralize exactly the 400 cc solution with sodium carbonate, covering the beaker with a watch glass during the process, and make up to 500 cc with water. Add now 10 cc of phenylhydrazin solution,[1] precipitating the furfurol as furfurol hydrazon.[2] Stir thirty minutes, preferably with an automatic stirrer, and filter the solution, using suction, into glass drying tubes about three-fourths inch in diameter and 6 to 7 inches long, drawn out at the lower end and filled with about one-half inch of glass wool in preference to asbestus. Remove adhering particles with a feather, and do not use over 100 cc of wash water. Dry the precipitate in a specially constructed air bath[3] at 55° to 60° C. for three hours. To hasten and perfect the drying a partial vacuum is made by drawing dry air slowly through the tubes by aid of a suction pump, the air supply being regulated by pinchcocks. The air before entering the tubes is conducted through sulphuric acid to dry it, and through a glass tube containing small pieces of marble to remove any sulphuric acid that might be carried over mechanically. Cool the tubes in a desiccator and weigh. Dissolve out the precipitate with hot alcohol and reweigh, and consider the loss in weight as furfurol hydrazon.

For the conversion of furfurol hydrazon to furfurol use the following factors:[4]

Furfurol = furfurol hydrazon × 0.538.
Arabinose = furfurol hydrazon × 1.229 + 0.0177.
Xylose = furfurol hydrazon × 1.031 — 0.001.
Pentose (average arabinose and xylose) = furfurol hydrazan × 1.13 + 0.0083.
Pentosan = pentose × 0.88.

Formulas.

Furfurol = $C_4H_3O—COH$.
Phenyl-hydrazin = $C_6H_5—NH—NH_2$.
Furfurol hydrazon = $C_4H_3OCHC_6H_5N_2H$.
Pentose = $(C_5H_{10}O_5)n$.
Pentosans = $(C_5H_8O_4)n$.

etermination of pentosans.

Analysts.	Sample II, Buffalo gluten feed.	Sample IV, blue lupine.
	Per cent.	*Per cent.*
United States Department of Agriculture, William H. Krug	*a* 19.80	*a* 7.45
New Hampshire Station, C. D. Howard	16.39	9.94
Columbia University, H. C. Sherman	15.30	8.75
Massachusetts Station:		
J. B. Lindsey	....	....
E. B. Holland	16.77	9.39
Average	16.15	9.36

a Excluded from average.

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[1] Twelve grams of phenylhydrazin and 7.5 grams of glacial acetic acid filled to 100 cc with water and well shaken.

[2] After the addition of the phenylhydrazin reagent, the solution should react *slightly* acid. In case this is not so, add the necessary acetic acid.

[3] See Twelfth Report of Mass. State Exp. Sta. 1894.

[4] See factors recommended further on, to be used in the future.

The method requires considerable time in its execution, and some practice is necessary in order to secure good results. The above figures therefore are quite encouraging. We note the presence of about 16 per cent of pentosans in the gluten feed, and nearly 9 (or one-half) per cent in the lupine.

RECOMMENDATION.

The place of the factors given on page 63 of the Methods of Analysis of the A. O. A. C. for 1895, for the conversion of the hydrazon into pentosans or of those in the preceding pages, I would recommend the adoption of the following:

Weight of hydrazon $\times 0.516 + 0.0104 \times 1.84 \div$ weight of substance taken $=$ pentosans.

Pentosans $\div 88 =$ pentoses.

Hydrazon $\times 0.516 + 0.0104 \times 1.65 \div$ amount substance taken $=$ xylan.

Hydrazon $\times 0.516 + 0.0104 \times 2.03 \div$ amount substance taken $=$ araban.

Xylan or araban $\div 0.88 =$ xylose or arabinose.

These factors have been very carefully worked out by Mann, Kruger, and Tollens.[1] It is well known that the pentosans, when distilled with hydrochloric acid, are somewhat decomposed. It is therefore not possible to calculate from the theoretical formula of the furfurol hydrazon, the amount of pentosans actually present in the substance. Tollens has distilled known amounts of pure furfurol, xylose, or arabinose, and from results thus obtained, deduced the above factors.

C.—Estimation of Galactan.

Bring 3 to 5 grams of substance free from fatty matters into a beaker of about 5.5 cm diameter and 7 cm deep, and add 60 cc of HNO_3 of 1.15 sp. gr. and evaporate the solution to exactly one-third of its original volume in a water bath at 94° to 96° C. Let the evaporated solution stand twenty-four hours, then add 10 cc of water and let stand twenty-four hours more, thus allowing the mucic acid to crystallize out. In case of most organic substances the mucic acid will be mixed with more or less impurities, and it is therefore necessary to filter, to wash with not over 20 cc of water, and bring the substance and filter back into the beaker. Add 25 to 30 cc of ammonium carbonate,[2] and bring the solution near to boiling. The $(NH_4)_2CO_3$ solution containing the mucic acid is filtered preferably into a platinum dish, the residue well washed, and the entire solution evaporated to dryness in a water bath, and then acidified with dilute HNO_3, and stirred with a glass rod. The mucic acid separates out, and after standing one-half hour the material is filtered either onto a tarred filter or into a weighed Gooch crucible, and washed with very little water (10 to 15 cc at most) with 60 cc alcohol and with ether, dried at 100° C. and weighed. After reducing to basis of 1 gram multiply by 1.333, which will reduce mucic acid to galactose. Galactose multiplied by 0.9 will give galactan. In case of sample 3 it will not be necessary to extract with ether or $(NH_4)_2CO_3$.

RESULTS OF GALACTAN DETERMINATIONS.

One chemist reports that he could do nothing with the method, and two did not try it. The following are the only results received:

Analysts.	Pure milk sugar.		Blue lupine.	
	Galactan.	Galactose.[a]	Galactan.	Galactose.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
United States Department of Agriculture, W. H. Krug	48.75	54.17	....	....
Columbia University, H. C. Sherman	46.95	52.17	13.11	14.57
Massachusetts Station:				
J. B. Lindsey	44.04	48.93	14.85	16.50
E. B. Holland	....	....	14.66	16.29

[a] Fifty is theoretical percentage.

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[1] Leitschrift für Angw. Chem. 1896, Hefts 2 and 7, Journal für Landw. 1896.

[2] Ammonium carbonate. Mix 1 part dry $(NH_4)CO_3$ with 19 parts water and 1 part NH_4OH.

While the results are fairly good, I am convinced that with a little practice still better ones could be obtained. The method is without doubt as accurate as that for estimating pentosans, and gives us a fairly correct idea of the amount of galactan present.

Recent investigations have shown that the hemi-cellulose galactans, while not so generally distributed as the pentosans, exist in considerable quantities, especially in leguminous plants and seeds. It has seemed wise, therefore, to encourage chemists to become accustomed to the use of the only quantitative method thus far proposed for their estimation.

This method consists in the oxidation of the galactan with dilute nitric acid and the weighing of the resulting mucic acid, $C4H4(OH)4(COOH)_2$. Scheele[1] was the first to recognize that by the oxidation of milk sugar with nitric acid mucic acid resulted. Pasteur found that it was the galactose of the milk sugar that yielded the mucic acid. Kent and Tollens[2] evaporated 100 grams of milk sugar with 1,200 cc of nitric acid of 1.15 sp. gr. in a water bath to one-third of its volume, and allowed the resulting solution to stand twenty-four hours for the mucic acid to crystallize. The precipitate filtered, dried at 100° C. and weighed was found to yield from 37.5 to 40 per cent of mucic acid. When pure galactose was used a double quantity (74 to 77 per cent) was obtained. Rischbieth Creydt, Hadecke, and Tollens[3] further perfected the method and used it for the estimation of galactan in a variety of substances. The method with slight modifications was sent out for trial this year together with samples 3 and 4. The percentage of galactan in each was requested. Sample 3 was pure milk sugar. Sample 4 was finely ground blue lupine seed.

AMENDED AND ADOPTED REPORT OF THE COMMITTEE OF RECOMMENDATIONS IN RELATION TO FOODS AND FEEDING STUFFS.

(1) That the diastase and Maercker methods be adopted as general methods for determination of starch and the Sachsse method for the determination of starch in potatoes and commercial starches.

(2) That the methods on page 62 (7) under (*a*), (*b*), and (*c*), and on page 63 under (*e*), be made official, and that (*d*), on page 62, remain a provisional method, and also that for the factors on page 63 the following be substituted:

Weight of hydrazon × 0.516 + 0.0104 ÷ by amount of substance taken = furfurol.
Furfurol × 1.84 = pentosans.
Pentoses × 0.88 = pentoses.
Furfurol × 1.65 = xylan.
Furfurol × 2.03 = araban.

H. J. WHEELER,
For Committee of Recommendations of Reporters.

The **PRESIDENT**. Are there any papers relating to this subject?

Mr. **LINDSEY**. I have the title of a paper by myself and Mr. Holland on the distribution of galactans in agricultural plants which I would like to offer. The paper will be presented to the meeting of the Agricultural Colleges and Experiment Stations and published in the proceedings of that association.

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[1] Opuscula Chemica et physica, Leipsig, 1789, p. 111.

[2] Ann. Chem., 227, p. 221.

[3] Landw. Vers. Sta. 39, p. 401.

THE PHLOROGLUCIN METHOD FOR THE ESTIMATION OF PENTOSANS.

By J. B. LINDSEY and E. B. HOLLAND.

Councler[1] has suggested that instead of phenylhydrazin, phloroglucin be employed for the precipitation and estimation of furfurol obtained by the distillation of various substances with dilute hydrochloric acid. Kruger and Tollens[2] have further studied and perfected the method, and recommend it as reliable for the estimation of pentosans in various coarse fodders, grains, and vegetables. The phloroglucin, just as the phenylhydrazin method, is based on the fact that the pentosans (araban, xylan, etc.) differ from other carbohydrates in that they yield furfurol instead of levulinic acid, upon digestion with moderately dilute hydrochloric or sulphuric acids. The first step necessary in both processes for a quantitative estimation is the conversion of the pentosans into furfurol, and its separation from the resulting by-products.

Phloroglucin method described.—Three grams of the material are brought into a 10-ounce flask together with 100 cc of 12 per cent hydrochloric acid (sp. gr. 1.06) and several pieces of recently heated pumice stone. The flask placed upon wire gauze is connected with a Liebig condenser and heat applied, rather gently at first, and so regulated as to distill over 30 cc in ten to fifteen minutes from the time that boiling begins. The 30 cc driven over are replaced by a like quantity of the dilute acid by means of a separatory funnel, and the process so continued as long as the distillate gives a pronounced reaction with anilin acetate on filter paper (a few drops of anilin in a little 50 per cent acetic acid). To the completed distillate is gradually added a quantity of phloroglucin[3] dissolved in 12 per cent hydrochloric acid, and the resulting mixture thoroughly stirred. The solution first turns yellow, then green, and very soon an amorphous greenish precipitate appears, which grows rapidly darker, till it finally becomes almost black. The solution is made up to 500 cc with 12 per cent hydrochloric acid, and allowed to stand over night. In case there is but very little furfurol in the substance tested, and the resulting distillate consequently small, it is best to add sufficient 12 per cent hydrochloric acid to the distillate before adding the phloroglucin solution, so that upon the addition of the latter solution the resulting mixture will contain approximately 500 cc. The amorphous black precipitate is filtered into a tared Gooch crucible through an asbestus felt, washed with 100 cc of water, dried to constant weight by heating three to four hours at 100° C., cooled, and weighed, the increase in weight being reckoned as phloroglucid. To calculate the furfurol from the phloroglucid,[4] use the following table:

Total weight of phloroglucid obtained:
0.2 divided by 1.82 = furfurol.
.22 divided by 1.839 = furfurol.
.24 divided by 1.856 = furfurol.
.26 divided by 1.871 = furfurol.
.28 divided by 1.884 = furfurol.
.30 divided by 1.895 = furfurol.
.32 divided by 1.904 = furfurol.

Total weight of phloroglucid obtained:
0.34 divided by 1.911 = furfurol.
.36 divided by 1.916 = furfurol.
.38 divided by 1.919 = furfurol.
.40 divided by 1.920 = furfurol.
.45 divided by 1.927 = furfurol.
.50 + divided by 1.930 = furfurol.

Furfurol divided by grams substance taken × 1.84 = pentosans.
Furfurol divided by grams substance taken × 1.65 = xylan.
Furfurol divided by grams substance taken × 2.03 = araban.

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[1] Chemikerztg, 1894, No. 51.

[2] Zeitsch, fur Ang. Chem., 1896, Heft II.

[3] Dissolve twice as much dry phloroglucin as furfurol expected in about 50 cc of 12 per cent hydrochloric acid. Bring the hydrochloric acid into a water bath, and stir thoroughly till the phloroglucin goes into solution.

[4] The phloroglucin is a complex substance of uncertain formula. It contains 63 to 64 per cent of carbon, and from 3.6 to 4.2 per cent of hydrogen. The factors for calculating the amount of furfurol from the phloroglucid were obtained after experimenting with known amounts of pure furfurol and phloroglucin.

The amount of pentosans was estimated by both the phenylhydrazin and the phloroglucin methods in the following substances:

Name of substance.	By phenylhydrazin.	By phloroglucin.
	Per cent.	*Per cent.*
English hay	21.28	22.50
High-grown salt hay	25.64	25.74
Branch grass	24.65	26.43
Low-meadow fox grass	27.98	27.91
Buffalo gluten feed	16.45	16.00
Lupine seeds	9.42	9.64

With two exceptions the two methods show very closely agreeing results. We propose to still further compare the methods in the near future. The phloroglucin method, on account of its greater simplicity, is much to be preferred.

The **President**. Are there any other papers on this subject? If not, the discussion of the report is in order. Has anyone any remarks to offer on the report just presented?

Mr. **Huston**. I do not think that report, which contains the result of a good deal of hard work, ought to pass without an expression of appreciation. I think there is no one here who knows anything about it or is capable of discussing it, and that is the reason it is not discussed. We appreciate how very hard the work is. It seems to me it is deserving of the very heartiest encouragement on the part of this association.

Mr. **Wiley**. I would like to say, Mr. President, that in our laboratory we have compared the method described by the reporter of collecting, filtering, and weighing the precipitate of furfurolhydrazon. We found it difficult to separate this precipitate easily from the beakers in which it is formed. It is very sticky, and requires a great deal of care to detach it from the sides of the beaker. This led Mr. Krug to introduce a modification of the process, which consists in dissolving the residue of the precipitate in alcohol instead of trying to collect it altogether on a filter. I would like Mr. Krug to explain this method.

Mr. **Krug**. In our laboratory we make no attempt to collect the precipitate which sticks to the beaker. It is washed with the prescribed amount of water, which is in turn passed through the filter tube. After drying, the precipitate is dissolved in warm alcohol and the solution collected in a weighed dish, the alcohol recovered, the residue dried at 60° and weighed.

Mr. **Wiley**. It seems to me that the members of this association do not appreciate the importance of these investigations. We have seen in the last few years a great deal of work done in this country on digestion experiments. In my own opinion the value of digestion experiments depends first of all, upon our knowledge of the material digested. Why should we be so careful to do all this work on digestion experiments without informing ourselves first of the nature of the materials which are used in the experiments? For this reason I heartily indorse what the reporter has said about the apathy existing with regard to this class of investigations. The remark the reporter made at the beginning of his address had much truth in it. He said he could read his paper now as well as at any time, for there was no one here who wanted to hear it. I hope what he said may induce the members of this association to take a greater interest in this class of investigations, for I believe it is along these lines we are to make our great progress. This is a line of work that demands our attention, and which ought to have it, and I hope future reporters may not have an opportunity to go upon the stage with a justification of the remark with which our distinguished friend introduced his address.

Mr. **Kilgore.** I would like to say just a word or two upon this subject. I think it is not exactly true, as Dr. Wiley says, that we do not have an interest in this work, because a great many do have an interest in it, but I think generally in the experiment stations the workers are engaged in a chemical line, and we have a certain amount of fertilizer work to do together with a great deal of miscellaneous work which must be done, and after this is done we have little time or energy to take up anything else; so I do not think it a matter of lack of interest, but rather lack of time and pressure of other work which we are forced to do, and I think this association could do no better than in some way to impress upon the authorities who have control of the time of station workers the importance of this class of work, and of putting more time upon it and less time upon regular routine, fertilizer, and miscellaneous work. I should like very much to see something of this kind done, because the workers with whom I have come in contact would like to do this work, but it requires time.

Mr. **Wiley.** I think Dr. Kilgore is quite right in that respect, because I know that in a great many of the stations the time of the chemists is taken up almost entirely, but I think there are others where there might be some little time devoted to these investigations. We have some things in our laboratory new to you, and if at any time during the progress of the meeting members could visit it we would be glad to have them do so.

The **President.** The association certainly will be glad to avail itself of Dr. Wiley's kind invitation to visit his laboratory and inspect points of interest.

We were considering the potash report. We have not discussed this report owing to the absence of the reporter at the time it was called upon. Has anyone any remarks to offer? Are there any papers on the subject of potash?

I would like to state for the benefit of those not here after the noon recess that it was moved by Dr. Wiley and the motion adopted that Messrs. Winton and Wheeler, who had been connected with the potash work for the past year or two, be requested to prepare a reply to some of the recent criticisms that have been made on the Lindo-Gladding method, and particularly, I believe, with regard to the article which Mr. Winton spoke upon this morning.

Mr. **Winton**. I neglected to call attention this morning to some samples prepared by the German Association of Experiment Stations and distributed around at the different stations for work.

Mr. **Kilgore**. The work two years ago on phosphoric acid, when we had the cooperation of some three or four German chemists, we had the criticism made from the director of the chemical station at Norway that with so small a quantity of material that we used in the analyses of phosphates it would be impossible for them to get anything like accurate or concordant results on materials they worked upon. The materials they used were so much larger that they could not work upon the small quantity we employed and get any results.

The **President**. Are there any further remarks on the subject of potash? If not, the next thing in order will be the report of the committee on the recommendations of the reporter on nitrogen.

Mr. **Wheeler**. The committee is ready to report on nitrogen, but not on potash. It wishes to call attention to the fact that in the case of nitrates the results were not fully satisfactory.

Mr. **Lindsey**. What method do you use in the nitrates?

Mr. **Wheeler**. The present modified Kjeldahl method, and I think that can be used for that purpose, according to our present regulations.

The **President**. You have heard the report of the committee. Are there any remarks on the subject?

Mr. **Wiley**. It seems to me that if the investigations of the reporter indicate that this method—the Ulsch-Street—is not applicable for pure nitrates, the reason for adopting it for nitrates mixed with other bodies ought to be plainly stated, so common people could understand them.

Mr. **Wheeler**. I feel sure that the association should understand all the circumstances connected with this recommendation. It may be that the trouble is owing to some little thing about the method which is not understood, but which can be understood later and which can be obviated. There is a feeling upon the part of some that on account of its rapidity and on account of the small amount of error when the percentage of nitrates is low it might be adopted for mixed goods. There are, I think, very good reasons why we ought to adopt, even for such goods, a method which will give first-class results.

Mr. **Van Slyke**. Another point which was brought up in the committee was this: The position which the committee takes is much more critical than that taken by the association; and although the results presented on the determination of nitrate of soda do not appear to be what we call first class, yet, compared with the results presented a few years ago for the determination of nitrates, they are entirely satisfactory, and there are not as great discrepancies in the form of nitrate of soda as we found when the other methods were adopted. The committee is more conservative than the association was, as a whole, when these other methods were adopted.

Mr. **Wiley**. I believe the method is good enough for nitrates in general, and that is the reason I do not want to see the committee recommend any recession in this method. If some of us are not able to get good results as analysts, I do not think we ought to condemn the method. Why ought we make this discrimination? I approve of the method, and therefore it seems to me that unless it can be proved that it is not a true method we ought not to let go the hold we have taken unless the committee could propose a better method for nitric nitrogen. Do not let us throw down until we are ready to build up. If it is good enough for nitric nitrogen and mixed fertilizers it is good enough for nitric nitrogen and unmixed fertilizers. I think the committee is a little bit too conservative right here.

Mr. **Street**. I would like to repeat something I said during the meeting of the committee. It seems to me that in a method of this kind the experiences of workers who have been using it for a long time ought to pass for more than those who have tried it for the first time. Any new method will probably give trouble the first time. We have used it continuously for five years. The first year we used it as a check method, and it gave perfect satisfaction. Since then we have used it exclusively. I agree perfectly with Dr. Wiley in urging that we retain the method until we get a better one.

Mr. **Kilgore**. The method as it stands right now is not an official method. I infer from Dr. Wiley's remarks that he considers it an official method. It is merely a provisional method, as I consider it now. Looking at these results on the pure soil and at those by the Keldow method, the question arises, Which gives the better results? If we look at the results by the Kjeldahl method, they are very good; if we look opposite, and see the man who gets good results with the Keldow method, we will see, also, that he gets good results by the other method. It appears to be rather a matter of the analyst.

Mr. **Davidson**. I think the method can be used for pure goods if well distilled, as far as you can distill. It may take forty minutes and it may take more than forty minutes. I think that as the method is now, forty minutes ought to be sufficient time, but distill until all has come off.

Mr. **Street**. I said "distill from thirty-five to forty minutes—nearly to dryness."

Mr. **Wiley**. Would it not be well to announce the rule in regard to those who have a right to vote on this? Most of us have no votes in this matter, and there might be some who may misunderstand the matter. I would suggest the president announce those who have a right to vote in this matter.

The **President**. There shall be one vote for each institution connected with the fertilizer work.

Mr. **Wheeler.** I would like to say that the committee had one other point to recommend which bears upon this, and that is, that the Ulsch method be tried, and be referred to the reporter for next year.

Mr. **Lindsey.** I would certainly object to the recommendation of the committee that the method be adopted for nitrogen nitrates and mixed goods if it can not recommend it for nitrogen and nitrates, that is, nitrate of soda. If it would determine one right it would determine others. My opinion is that the method is safe to recommend for a method of determination of nitrates; but if the committee does not feel it is safe for unmixed goods, then it should not be adopted for either.

Mr. **Frear.** I think we shall find from time to time our special fertilizers will increase in numbers. I notice that tendency in our own State. We have an increased tendency toward the use of nitrates, so we may run upon a snag there. I have always felt that we ought not to be guided by the logic of a method, but by what we find to be the effect in practice concerning the ease with which it can be carried out by the young men upon whom we have to place the burden of the work in our laboratories. For that reason I am inclined to be on the side of the committee's recommendation that we do not say the method is a bad one for the determination of nitric nitrogen in pure goods, but we have found such difficulty in the determination of the nitric nitrogen, even by fairly experienced analysts who do not have occasion to use this method every day, that we hesitate to make a general recommendation of the method for the use of all men who have this fertilizer control work to do. There are only a few fertilizers in the United States where the determination of nitric nitrogen can be carried out. In our own State we make a certain number upon each fertilizer. The character of the determinations to be made is fixed by the department of agriculture of the State, which pays for the work, and it is ready to pay for only so many determinations; and, it goes further, it is willing to print only so many, no matter how many we contribute. So we soon reach a limit. I think, therefore, we will find there will be hereafter, as in the past, a great many analysts who would have occasion to use this method only infrequently, and they would have the same difficulty as heretofore, unless we can strike upon some modification.

Mr. **Bigelow.** I do not think many of our association methods or many of the methods used in analytical chemistry are of much value in the hands of others than experts, and I do not think a good method should be abandoned because it requires some experience. If there are those who have to make determinations of nitric nitrogen who can not make them by this method on account of having so little work to do in this line, I think it would be well for them to use a method they can, and give those who are expert an opportunity to use a more perfect method.

Mr. **Frear.** When I spoke of experts I did not mean an expert in general, but an expert on the subject in general. I do not know where the trouble is, but they have tried several modifications with no better result. There is no reason why it should not be continued as an optional method for the determination of nitrogen in nitrates. Do I understand it is the intention of the committee to eliminate altogether from the list the methods which may be used, or simply to make it official for mixed goods and let it stand optional for pure nitrates?

Mr. **Wheeler**. The recommendation was to make it an official method in the case of the determination of nitrates and mixed goods.

Mr. **Frear**. And make no mention of its application to other determinations?

Mr. **Wheeler**. Not at all. I will say that one of my assistants, who is an excellent analyst and has been working in the laboratory for eight years, failed to get good results, and for that reason asked the reporter not to report his results. They were as good as some of the results here, but he was not satisfied.

Mr. **Street**. In our own case during the last season we have had to make over 200 determinations of nitrates, and I am sure there are stations which have to make a corresponding number. We can use this method all right, and I can not see why the experience of those who make an occasional determination should rule out our experience where we have made hundreds of them. Why can not we have this method adopted as a regular method? We can use it. Give us the opportunity of using this method and of feeling we are official.

Mr. **Wiley**. I do not want to make an amendment, but I do not want to put ourselves in a hole. I do not want this society to go before the world recommending a method for the determination of a matter which is very small in quantity because a little difference will not count, while they are afraid to recommend it for a larger amount where the difference would count. That is not right. Let us be fair with the world and ourselves. If the committee think it is not good enough to use, let it say so.

Mr. **Lindsey**. To get out of this difficulty, would it not be wise for the committee to reconsider this point before it makes a final report?

Mr. **Van Slyke**. I believe there is no motion before us now, and I will bring the matter into specific form. I move that the Ulsch-Street method stand as it does now and be referred to the reporter on nitrogen for next year to test with special reference to nitrates in pure goods.

Mr. **Wheeler**. I second that motion.

Motion carried.

Mr. **Wheeler**. The second recommendation of the committee, that the heretofore so-called Fassbender method be referred to the reporter on nitrogen for next year for further investigation, and that he look into the matter of attaching a correct name to the method.

Recommendation adopted.

The meeting was then adjourned until Saturday morning.

SECOND DAY.

SATURDAY—MORNING SESSION.

The association met at 10 o'clock, and the president called for the report of the committee on recommendations.

Mr. **Wheeler**. I will read at the present time the report of the committee on recommendations so far as it has agreed on the points which have been referred to it by the reporters and by the association.

The committee's report was read, and after a brief discussion and making a few changes was adopted.

The **President**. The next thing in order is the consideration of the report on phosphoric acid.

Mr. **McDonnell**. I would say that some of the reports did not reach me until two days before the meeting, and I was considerably rushed in tabulating them. I hope the association will bear with me and pardon the number of defects in my report.

REPORT ON PHOSPHORIC ACID.

By H. B. McDonnell.

Following the usual custom, the reporter on phosphoric acid sent a circular letter early in the year to a number of chemists who were known to be interested in the determination of phosphoric acid in fertilizers, asking for their cooperation in the work.

Chemists representing twenty laboratories signified their willingness to take part in the work.

Samples were accordingly sent, and with them the following letter of instructions:

College Park, Md., *February 20, 1896.*

Dear Sir: I send you herewith by express three samples for testing methods for determination of phosphoric acid for the Association of Official Agricultural Chemists.

The association last year directed the reporter on phosphoric acid to make a further test of the volumetric method and also to include in the work the magnesia or citrate method.

For this purpose three samples have been selected as follows:

No. 1. Ground South Carolina rock.
No. 2. Dissolved South Carolina rock.
No. 3. Complete fertilizer, made by mixing 150 samples of miscellaneous "complete" fertilizers.

You are requested to determine total P_2O_5 in all, and soluble and insoluble in Nos. 2 and 3 by the following methods:

1. Volumetric method as modified by reporter.
2. Volumetric method (Chem. Bul. No. 46, U. S. Dept. of Agr.).
3. The official method (Chem. Bul. No. 46, U. S. Dept. of Agr.).
4. A magnesia or citrate method.
5. A magnesia or citrate method as carried out by Glaser (American Fertilizer, Sept., 1895).
6. By weighing the ammonium-phosphomolybdate as carried out by Gladding (Jour. Amer. Chem. Soc., Jan., 1896).

1. The reporter finds that the volumetric method as published is capable of being further simplified and recommends the following method:

Dissolve the phosphate as in the official method, using preferably 40 cc strong HNO_3 with a little HCl, make up to definite volume, take an aliquot portion corresponding to 0.4 gram substance; if over 5 per cent P_2O_5 be present half this amount. Add ammonia in slight excess, then HNO_3 in slight excess and warm to about 50° C. and add the regular molybdic solution in excess, using 75 to 80 cc for each 0.1 gram P_2O_5 present, and in no case less than 10 cc; stir well, let stand for about thirty minutes at 40 to 50° C., stirring several times at intervals; filter through good filter paper about 9 cm in diameter, on ordinary funnel without suction; wash precipitate with water at ordinary temperature, first by decantation and then on the filter; when filtrate measures about 250 cc test filtrate, as it drops through the funnel, with a small strip of litmus paper; wash once more, stirring the precipitate with the water jet, and test again. When two successive tests show no acidity of filtrate the washing is sufficient. Remove filter and contents to beaker; add standard KOH in excess and stir till precipitate is dissolved and titrate with standard HNO_3, using phenolphtalein as indicator. The standard solutions are made as directed on page 14, Bulletin 46, Chemistry Division, United States Department of Agriculture.

2 and 3. As in Chemical Bulletin No. 46, United States Department of Agriculture.

4. Citrate method:

Make solution of phosphate according to one of the official methods. Take aliquot corresponding to 0.4 gram for ordinary work or twice this amount for ordinary "insolubles;" make alkaline with ammonia and add ordinary ammonium citrate till clear; cool rapidly, if necessary, and add magnesia mixture slowly from a burette, stirring vigorously; use from 10 to 30 cc magnesia mixture. The latter is sufficient for 30 per cent P_2O_5 on the basis of 0.4 gram substance. Add ammonia in sufficient amount to insure the presence of 3 per cent of free NH_3 in the solution; stir well every half hour and filter after two to five hours. The longer time is required when the amount of P_2O_5 is small. Wash and ignite in the ordinary way. If white residues are desired the last washing should be made with a solution containing 2½ per cent NH_3 and about 40 per cent NH_4NO_3.

Wiley and Runyan (Jour. Amer. Chem. Soc., July, 1895) recommend the addition of a phosphate solution of known strength when determining P_2O_5 in insoluble residues, etc., which contain less than 5 per cent P_2O_5, so that the total amount present in solution will be equivalent to 10 per cent. This method should be given a trial with the "insolubles" of samples Nos. 2 and 3.

5. Citrate method as executed by Glaser:

(*a*) 500 grams citric acid dissolved in 500 cc of water.

(*b*) Magnesia mixture is prepared by using instead of magnesium chlorid an equivalent amount of magnesium sulphate.

Dissolve the phosphate and take aliquot in the ordinary way except for insolubles; filter solution from insoluble residue and use the whole amount; add strong ammonia in excess and citric acid solution from a burette till the solution is just clear; note the amount and add as much more; cool the solution. Be sure same is alkaline and add twice as much magnesia mixture as citric acid. If more than 5 cc of citric acid have been used the magnesia mixture may be run in quickly. Stir vigorously for several minutes and let settle till liquid becomes clear and stir once again. Filter after one to one and one-half hours, and wash with 2½ to 3 per cent ammonia. For the last washing use a few drops of this solution made strong with ammon. nitrate.

6. The method of Gladding is capable of giving excellent results, and it is the opinion of the reporter that this method will prove of more value to the association than any of the citrate methods. It is as follows:

Make solution and take aliquot in ordinary way; add 25 cc ammonia sp. gr. 0.9 and nitric acid sp. gr. 1.42 till acid; place beaker and contents in water-bath at 50° C.; add ordinary molybdate solution from a burette at the rate of three drops per second, with constant stirring; 50 cc may be added in five minutes. After about 10 cc in excess has been added allow beaker to remain in the bath for ten minutes and filter through a weighed filter paper (reporter suggests a Gooch crucible). Test filtrate, without the washings, by adding 5 cc molybdic solution and replacing in bath for ten minutes. Wash precipitate with nitric acid and water 1:100; three generous washings by decantation and three on the filter and a final washing with water are sufficient. Drain paper and contents for a few minutes on filter or blotting paper and dry to constant weight in oven at 105° C. Use double-walled oven containing dilute glycerol sp. gr. 1.16 (or saturated brine solution). Start drying on the upper shelf and end on lower shelf of oven. The drying requires three or four hours. The precipitate contains 3.76 per cent P_2O_5.

If you do not care to do all the work outlined above and can undertake part it will be appreciated, as will also any further trials of the methods or modifications that you may care to undertake. In reporting results give results from same flask only on the same horizontal line and use letters *a*, *b*, *c*, etc., to indicate same. One flask of solution will be sufficient to make one test by several of the methods, and in this way much time may be saved.

In reporting results please give approximate date of making the analyses. It is desirable that the work be done within three months after receiving the samples. Please give full notes, etc., of variations from published methods and send report of results at least ten days before the next meeting of the association.

Yours, truly,

H. B. McDONNELL, *Reporter.*

Reports have been received of the work of seventeen chemists, representing eleven laboratories. Most of the chemists reported duplicate or triplicate results; some as many as nine determinations by the same method on one sample. For lack of space and to facilitate reference only the means are given in the tables. The results reported by the various analysts are as follows:

TABLE I.—TOTAL PHOSPHORIC ACID.

Analyst.	Official gravimetric.	Volumetric.	Modified volumetric.	Gladding	Citrate.	
					(*a*)	(*b*) Glaser's.
Sample No. 1.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
C. L. Hare, Alabama	27.50	27.75	27.80			
J. H. Pratt, Florida	27.75	27.92	27.94			27.79
L. H. Merrill, Maine	[0]28.47				28.52	28.69
C. Glaser, Baltimore, Md	[0] [1]28.76 [2]28.41		[0]28.38	[0] [3]28.72 [4]28.06 [0] [5]27.94		28.35
F. B. Bomberger, Maryland			27.40		[0] [6]27.78 [0] [7]28.14 [8]28.16	
W. Skinner, Maryland	27.85	27.35	27.30		[0] [6]27.44 [7]27.94	[0] [6]27.72 [7]27.92
F. P. Veitch, Maryland	27.82	27.43	27.48	27.65	28.00	28.11
W. M. Allen, North Carolina	28.00					
H. K. Miller, North Carolina	27.95	27.84				
B. W. Kilgore, North Carolina		27.90				
C. B. Williams, North Carolina		27.95				
M. S. McDowell, Pennsylvania	[0]28.43	27.04	28.08	28.41	28.22	28.47
E. G. Runyan, District of Columbia	27.55	27.62	27.63	[0]26.63 [0]26.81	27.63	27.59
C. H. Jones, Vermont	27.89	[0] [9]26.74 27.42	27.38	27.38	28.01	28.14
F. W. Woll, Wisconsin	28.16	27.59	28.12			
J. P. Street, New Jersey	27.68	27.54	27.70		27.79	28.04
Number averaged	11	12	10	4	8	9
Average	27.87	27.66	27.68	27.88	27.91	28.11
Sample No. 2.						
C. L. Hare, Alabama	15.50	15.74	15.81			
J. H. Pratt, Florida	15.54	15.54	15.55			15.52

[0] Omitted from average.

[1] Before ignition with HNO_3. Omitted from average.

[2] After ignition with HNO_3. Omitted from average.

[3] Two and one-half hours drying. Omitted from average.

[4] Four hours drying.

[5] Four hours drying, wash water milky. Omitted from average.

[6] Stood 2 hours. Omitted from average.

[7] Stood 21 hours. Omitted from average.

[8] Stood 24 hours.

[9] Obtained when solution made as per (a_4) page 12, official method. Omitted from average.

TABLE I.—TOTAL PHOSPHORIC ACID—Continued.

Analyst.	Official gravimetric.	Volumetric.	Modified volumetric.	Gladding.	Citrate.	
					(a)	(b) Glaser's.
Sample No. 2—Continued.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
L. H. Merrill, Maine	15.42				15.66	15.76
C. Glaser, Baltimore, Md	[0] [1] 15.68 [2] 15.65		[0] [3] 16.13	15.28		15.47
F. B. Bomberger, Maryland			[4] 15.25		[0] [5] 15.28 [0] [6] 15.54 [7] 15.63	
W. Skinner, Maryland	15.40	15.35	15.42			[10] 15.23
F. P. Veitch, Maryland	15.37	15.38	15.53	15.44	15.44	15.47
W. M. Allen, North Carolina	15.63					
H. K. Miller, North Carolina	15.63	15.54				
B. W. Kilgore, North Carolina		15.61				
C. B. Williams, North Carolina		15.58				
M. S. McDowell, Pennsylvania	[0] 16.11	[0] 15.95	[0] 16.73	15.92	15.67	15.79
E. G. Runyan, District of Columbia	15.40	15.34	15.42	[0] 15.05	15.44	15.43
C. H. Jones, Vermont	[0] [4] 15.34 15.27	[0] [8] 14.66 15.30	15.26	15.41	15.42	15.70
F. W. Woll, Wisconsin	15.19	15.44	15.66			
J. P. Street, New Jersey	15.61	15.55	15.77		15.59	15.57
Number averaged	12	11	9	3	7	9
Average	15.46	15.47	15.48	15.38	15.55	15.58
Sample No. 3.						
C. L. Hare, Alabama	11.02		11.00			
J. H. Pratt, Florida	11.41	11.41	11.42			11.42
L. H. Merrill, Maine	11.58				11.52	11.58
C. Glaser, Baltimore, Md	11.39		[0] 12.12	11.74		11.45
F. B. Bomberger, Maryland			11.23		[5] 11.16 [6] 11.25 [7] 11.35	
W. Skinner, Maryland	11.31	11.32	11.35		11.31	11.34
F. P. Veitch, Maryland	11.45	11.20	11.25	11.45	11.34	11.34
W. M. Allen, North Carolina	11.53					
H. K. Miller, North Carolina	11.60	11.48				
B. W. Kilgore, North Carolina		11.49				
C. B. Williams, North Carolina		11.46				
M. S. McDowell, Pennsylvania	11.89	[0] 12.14	[0] 12.23	11.70	11.59	11.60
E. G. Runyan, District of Columbia	11.44	11.34	11.39	11.07	11.28	11.57
C. H. Jones, Vermont	[0] [8] 11.29 11.31	[0] [8] 10.28 11.34	11.43	11.60	11.38	11.48
F. W. Woll, Wisconsin	11.40	11.18	11.63			
J. P. Street, New Jersey	11.57	11.54	11.54		11.47	11.46
Number averaged	13	10	9	5	8	9
Average	11.45	11.38	11.36	11.51	11.41	11.47

[0] Omitted from average.

[1] Before ignition with HNO_3. Omitted from average.

[2] After ignition with HNO_3. Omitted from average.

[3] End point not distinct. Omitted from average.

[4] Stood 2 hours at 50°.

[5] Stood 2 hours. Omitted from average.

[6] Stood 21 hours. Omitted from average.

[7] Stood 24 hours.

[8] Obtained when solution made as per (a_4), page 12, official method. Omitted from average.

TABLE II.—SOLUBLE PHOSPHORIC ACID.

Analyist.	Official gravimetric.	Volumetric.	Modified volumetric.	Gladding.	Citrate.	
					(a)	(b) Glaser's.
Sample No. 2.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
C. L. Hare, Alabama	12.49	....	12.41	....	....	....
J. H. Pratt, Florida	12.50	....	12.55	....	....	12.44
L. H. Merrill, Maine	12.56	....	....	....	....	....
C. Glaser, Baltimore, Md	[0] [2] 12.41 [1] 12.54	....	[3] 12.84	....	....	12.32
W. Skinner, Maryland	12.37	....	[3] 12.36	....	12.51	12.48
F. P. Veitch, Maryland	12.58	12.37	[0] [5] 12.66 12.58	....	12.62	....
M. E. McDonnell, Pennsylvania	12.80	12.93	12.81	12.48	12.73	12.61
M. S. McDowell, Pennsylvania	12.81	12.89	13.00	12.77	12.49	12.60
E. G. Runyan, District of Columbia	12.53	12.41	12.48	[0] 11.80	12.60	12.44
C. H. Jones, Vermont	[0] 11.63	[0] 11.78	[0] 11.57	[0] 11.84	[0] 11.65	[0] 11.73
Number averaged	9	4	8	3	5	6
Average	12.62	12.65	12.63	12.63	12.59	12.48
Sample No. 3.						
J. H. Pratt, Florida	5.26	....	5.28	....	....	5.23
L. H. Merrill, Maine	5.31	....	....	....	....	....
C. Glaser, Baltimore, Md	5.21	....	5.56	[4] 5.52	....	5.20
W. Skinner, Maryland	5.90	....	5.82	....	5.86	5.70
F. P. Veitch, Maryland	5.79	5.71	5.74	....	5.82	....
M. E. McDonnell, Pennsylvania	5.83	6.05	6.09	5.65	5.65	5.73
M. S. McDowell, Pennsylvania	5.84	5.85	5.99	5.80	5.60	5.66
E. G. Runyan, District of Columbia	5.70	5.76	5.84	5.44	5.46	5.79
C. H. Jones, Vermont	[0] 4.77	[0] 5.03	[0] 5.07	5.41	[0] 4.64	[0] 4.98
Number averaged	8	4	7	5	5	6
Average	5.60	5.84	5.76	5.56	5.68	5.55

[0] Omitted from average.

[1] Before igniting with HNO_3.

[2] After igniting with HNO_3. Omitted from average.

[3] End point not distinct.

[4] Darkening around edge.

[5] Four hours drying, wash water milky. Omitted from average.

TABLE III.—INSOLUBLE PHOSPHORIC ACID.

Analyst.	Official gravimetric.	Volumetric.	Modified volumetric.	Gladding.	Citrate.		
					(a)	(b) Glaser.	Runyan and Wiley.
Sample No. 2.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
C. L. Hare, Alabama	0.55	....	0.47	....	....	....	....
J. H. Pratt, Florida	.54	....	.54	....	....	0.53	....
L. H. Merrill, Maine	.33	....	....	....	....	....	....
C. Glaser, Baltimore, Md	[0] .55 .66	....	.51	....	....	.49	....
W. Skinner, Maryland Agricultural College	.73	0.69	.72	....	....	.52	....
F. P. Veitch, Maryland Agricultural College	.75	.76	[1] .76	0.64	[2] 0.63	[3] .82	....

[0] Omitted from average.

[1] Stood ½ hour at 40 to 50° before filtering.

[2] Stood 20 hours before filtering.

[3] Stood 8 hours before filtering.

TABLE III.—INSOLUBLE PHOSPHORIC ACID—Continued.

Analyst.	Official gravimetric.	Volumetric.	Modified volumetric.	Gladding.	Citrate.		
					(*a*)	(*b*) Glaser.	Runyan and Wiley.
Sample No. 2—Continued.							
M. E. McDonnell, Pennsylvania	*Per cent.* .64	*Per cent.* .63	*Per cent.* .63	*Per cent.* .61	*Per cent.* .52	*Per cent.*	*Per cent.* ....
M. S. McDowell, Pennsylvania	.67	.70	.69	.74	.56	.68	....
F. G. Runyan, United States Department of Agriculture	.54	.53	.54	....	....	....	0.48
C. H. Jones, Vermont	.41	.47	.43	.33	.51	.42	....
Number of analysts	10	6	9	4	4	6	1
Average	.58	.63	.59	.58	.56	.58	.48
Sample No. 3.							
C. L. Hare, Alabama	2.28	....	2.31	....	....	....	....
J. H. Pratt, Florida	2.45	....	2.49	....	....	2.43	....
L. H. Merrill, Maine	2.30	....	....	....	....	....	....
C. Glaser, Baltimore, Md	2.22	....	2.40	....	....	2.24	....
W. Skinner, Maryland Agricultural College	2.39	2.27	2.29	....	....	2.33	....
F. P. Veitch, Maryland Agricultural College	2.26	2.25	[*]2.25 2.21	2.16	[1]2.10	[2]2.07	....
M. E. McDonnell, Pennsylvania	2.62	2.66	2.63	2.48	2.63	2.67	....
M. S. McDowell, Pennsylvania	2.63	2.59	2.55	2.37	2.47	2.42	2.38
E. G. Runyan, United States Department of Agriculture	2.26	2.24	2.24	2.26	....	....	2.47
C. H. Jones, Vermont	2.14	2.37	2.30	2.22	2.27	2.41	....
Number of analysts	10	6	9	5	4	7	2
Average	2.36	2.28	2.38	2.30	2.37	2.37	2.43

[*] Omitted from average. [1] Stood 20 hours before filtering. [2] Stood 8 hours before filtering.

These results are about as good as could reasonably be expected with the volumetric and citrate methods, with which some of the analysts were probably not very familiar.

The results by the official gravimetric method, however, are not as concordant as they should be. In the case of the total phosphoric acid the difference between the highest and lowest results are 1.29, 0.92, and 0.87 per cent on samples Nos. 1, 2, and 3, respectively, being, approximately, 4.50, 6, and 7.50 per cent of the total present.

The results show that the volumetric method is reliable, and that the modifications suggested by the reporter will give results equally as good as the method as published, and is considerably simplified by doing away with the potassium nitrate and nitric acid washes and using only water.

My experiments show that the acid substance which is precipitated more or less from molybdate mixture and which is generally called molybdic acid, but which is probably a hydrated acid ammonium salt of molybdenum, is quite soluble in water—nearly as much so as it is in dilute nitric acid, as the following experiments indicate:

1. Precipitated "molybdic acid" from 100 cc molybdate solution by adding ammonia till nearly neutral and warming; threw the precipitate on a filter and washed with water. After the first washing the precipitate rapidly dissolved, and was

thrown down again as the solution mixed with the first washings. When filtrate measured 450 cc all of the precipitate on the filter had dissolved.

2. Precipitated "molybdic acid" as above; filtered and washed precipitate several times with water; then collected 25 cc of the filtrate and passed it over the precipitate twice; evaporated the 25 cc to dryness and heated in oven to drive off nitric acid, and titrated with the standard alkali (as used in determination of phosphoric acid) and found that 13.2 cc were required to neutralize, equivalent to 52.8 cc for 100 cc of water. This result is evidently too low, because ammonium nitrate was still present and retarded the solution.

3. Precipitated "molybdic acid" as above and brought an equal amount of the precipitate on each of four 10 cm filters till they were nearly full of the precipitate; washed two with water and two with nitric acid wash solution. Four washings (total, 110 cc) of the latter, and five of the former (total, 135 cc) were required to dissolve the contents of each filter.

When it is remembered that in washing with nitric acid we introduce much more acid than is removed in the operation, and which must in turn be washed out with other washes, the saving of time is apparent.

The citrate methods give fair results and, no doubt, would be useful to some. The method as carried out by Glaser shows no advantage over the simpler method.

Citrate methods have a tendency to give low results when small amounts of phosphoric acid are present. The method proposed by Runyan and Wiley for overcoming this difficulty by adding a known amount of phosphoric acid, in the form of a soluble phosphate, to each determination and subtracting it from the final result has been tried by but two analysts. These results do not indicate the necessity for this precaution.

The results on insoluble phosphoric acid are not very satisfactory on sample No. 2. The difference between the highest and the lowest results is 0.42 per cent, which is 73 per cent of the average. On sample No. 3 the results are better. Difference between highest and lowest is 0.39 per cent, which is 16 per cent of the average.

NOTES OF ANALYSTS.

C. L. Hare, Alabama.—The volumetric method, as modified by the reporter, gives satisfaction with all who have tried it here. The only objection is the end reaction with phenolphtalein. It is not sharp enough. This, however, may be overcome in a degree by using small equivalents. The error occasioned by this use of smaller amounts is counterbalanced by the smaller error in reading the end reaction.

The chances for error in the method are much less than in the gravimetric.

I find the ordinary funnel and filter paper holds better than platinum cones with asbestus, or Gooch crucibles with disk of filter paper.

L. H. Merrill, Maine.—I have been unable to get a sharp end reaction with the volumetric method, the color disappearing so gradually that it was impossible to read within a cubic centimeter.

F. P. Veitch, Maryland.—

Official method: Precipitates made white by using a solution of 2½ per cent ammonia, containing 20 per cent ammonium nitrate before ignition.

Volumetric method: Used Gooch crucible with two disks of filter paper for filtering; 225 cc wash water in all cases freed precipitate of acid. Would suggest that for percentages above 18 and below 2 a little longer time in the bath would be advisable; say, eight to ten minutes. Used standard sulphuric acid for titrating.

Modified volumetric method: Filtered same as in method above; 250 cc wash water sufficient in all cases. Results on reporter's samples confirm quite a lot of work on other samples by this modification, which I prefer to the regular volumetric.

Citrate method: Used about twice as much magnesia mixture as required to precipitate the phosphoric acid present. The use of the blast in the final ignition in this method seems to be necessary, otherwise results are too high. Results on insolubles, even after long standing, are a little low.

Citrate method, Glaser's modification: No advantage over other citrate method except in making up citric acid solution. Precipitates came down slowly. Did not stir constantly for half an hour, but for three to five minutes five or six times in three hours.

Gladding method: There is danger of loss in neutralizing the great amount of strong ammonia added. Gooch crucible and two disks of filter paper used for the filtration. Washed more than recommended, which does not seem to be sufficient. Washed about 150 cc, or till neutral to litmus.

B. W. Kilgore.—The volumetric method has proved to be entirely satisfactory in the hands of all the workers in this laboratory.

E. G. Runyan.—Results by weighing ammonium-phospho-molybdate were very unsatisfactory. On filtering through paper and washing as directed, the filter was partially oxydized during the process of drying. When a Gooch was used and the precipitate washed with dilute acid the results appeared to be too high, while, if the final washing was made with water, some of the precipitate always ran through the filter.

J. P. Street.—I had little difficulty with any of the determinations, except with those on sample 1, where I had considerable trouble in getting satisfactory results, especially with the official method.

During the past season I have used a method for phosphoric acid which has given very satisfactory results. It is the Kilgore method with a few modifications. The following is the mode of procedure:

Treat 2 grams of the sample with 5 cc of magnesium nitrate, evaporate, ignite, and dissolve in hydrochloric acid. Take an aliquot portion of the solution (equal to 0.25 gram), 5 cc of concentrated nitric acid, then neutralize with ammonia and clear with a few drops of nitric acid. Heat on the water bath to the temperature of 60 to 65° C., add 50 cc of freshly filtered molybdic solution for each decigram of P_2O_5 present, and digest at this temperature for twenty minutes. Proceed as indicated under (2) (b_1) in Bulletin 46, United States Department of Agriculture, page 14.

I found that solution in nitric and hydrochloric acids would not always answer, so I used the magnesium nitrate uniformly on all samples. Six minutes' heating in many cases will not precipitate the ammonium-phospho-molybdate; the time I indicate—twenty minutes—sufficed in every case. For some reason or other, by this method less water is needed to thoroughly free the precipitate from all traces of acidity; 100 cc were ample in every case. The tabulated comparative results which I inclose were all obtained by this modification.

Comparative results with 326 samples are given, as follows:

	Per cent.
Total phosphoric acid, 276 samples—	
Average by official gravimetric method	10.70
Average by volumetric method	10.72
Insoluble phosphoric acid, 50 samples—	
Average by official method	2.61
Average by volumetric method	2.55

RECOMMENDATIONS.

I would recommend the adoption of the volumetric method, as modified, as one of the official methods. Also that the use of sulphuric or hydrochloric acids be allowed for the standard acid as well as nitric acid.

Amended and adopted report of the committee on recommendations in relation to phosphoric acid.

It is recommended—

(1) That the volumetric method be referred to the reporter for 1897 with the request that it be further investigated with a variety of phosphatic materials.

(2) That on page 14, section 2, under (*b*), the time of digestion be made ten to fifteen minutes instead of six minutes as at present; also that (b_1), paragraph 2, in line 6, in the direction for washing, the following be inserted: "Wash five to six times with water, using in all 150 to 250 cc."

(3) That the methods for iron and aluminum in phosphates be referred to the reporter for 1897.

(4) That the methods of determining available phosphoric acid in phosphatic slags be investigated by the reporter for next year.

H. J. Wheeler,
For the Committee on Recommendations of Reporters.

The **President**. The next thing in order is the presentation of papers. Are there any papers to be presented?

Mr. Huston read a paper on basic slag.

ACTION OF AMMONIUM CITRATE AND CITRIC ACID ON BASIC SLAG.

By H. A. HUSTON and W. J. JONES, Jr.

In view of the various methods proposed for determining the available phosphoric acid in basic slag, it may be of interest to examine the action of the substances used for the purpose, when they are applied under different conditions of time, temperature, quantity, acidity, and concentration.

In the work here reported all digestions were made in closed flasks placed in the digesting apparatus described in Bulletin 54, Indiana Agricultural Experiment Station, and Wiley's Agricultural Analysis, page 142.

The basic slag used was made at Pottstown, Pa., and contained 18.24 per cent total phosphoric acid. It was ground to pass 100-mesh sieve.

Unless otherwise stated, 100 cc of the neutral solvent, 110 cc of solution corrected for basicity, and 2 grams of slag were used. To save space only averages are given. Duplicate determinations were always made, and sometimes the number was increased to four.

As some of the proposed methods attempt to correct the basicity of the slag by the addition of a definite amount of acid before the addition of the citrate solution, two series were made. In one series the slag was treated with neutral ammonium citrate, while in the second series enough citric acid was added to neutralize the basicity of the slag. This amount of citric acid—0.52 gram of citric acid per gram of slag—was determined according to Wagner's method, shaking for one-half hour 5 grams of slag with 500 cc of 1 per cent solution of citric acid. Further investigation of this step might be useful, for we found on adding the above amount of citric acid—0.52 gram per gram of slag—to a fresh portion of slag and shaking one-half hour, that the mixture was not neutral, but contained free acid—only 0.362 gram of acid per gram of slag having been neutralized. When 0.362 gram of citric acid per gram of slag was shaken for one-half hour with a fresh portion of slag, only 0.275 gram of citric acid was neutralized.

Wishing our work to be in some degree comparable with that of Wagner, we used the amount of citric acid indicated by the first titration—0.52 gram of citric acid per gram of slag. But this does not make our solution the same as Wagner's solution, which contains free acid before adding the amount required by the results of the neutralization test.

I.—INFLUENCE OF TIME OF DIGESTION.

[Temperature, 65° C.]

Per cent phosphoric acid dissolved.

Time of digestion.	Series I. Neutral citrate.	Series II. Basicity corrected.
½ hour	6.90	9.61
1 hour	7.78	10.66
2 hours	8.52	11.18
3½ hours	9.00	11.60
5 hours	9.15	11.86
7½ hours	9.02	11.86
10 hours	9.56	11.82

The form of the curve is very similar to the form of the time curve for phosphate of lime in bone products.

In all our work on phosphates we make the time curve first. So far as possible we wish to deal with completed reactions. In this case the solution was practically complete in five hours. This length of time was therefore adopted as the standard time for the remainder of the work.

Even when the basicity is corrected by the addition of acid, the reaction is far from complete in one-half hour even at a temperature of 65°.

II.—INFLUENCE OF TEMPERATURE.

[Time, five hours.]

Per cent phosphoric acid dissolved.

Temperature of digestion.	Series I. Neutral citrate.	Series II. Basicity corrected.
40° C	8.10	11.36
50° C	9.27	11.46
65° C	8.90	11.81
75° C	9.12	11.91
85° C	8.88	11.81

In seventy-two hours, at room temperature, about 25° C., with neutral solution 7.54 per cent were dissolved.

It will be seen that when the time of digestion is extended to five hours the temperature exerts very little influence. This is not equivalent to saying that the temperature would not exert any influence in the cases where one-half-hour digestions were used.

In its temperature relations slag differs radically from the phosphates of alumina and iron, and also bone, and South Carolina, Florida, or Tennessee rock. It somewhat resembles precipitated phosphate of lime obtained in the acid process of glue making when the latter material is subjected to one-half-hour digestion at various temperatures.

III.—INFLUENCE OF ACID AND ALKALI.

[Time, five hours. Temperature, 65° C. Volume, Series I, 110 cc; Series II, 120 cc.]

Per cent phosphoric acid dissolved.

Amount of acid or alkali added.	Series I. Neutral citrate and acid or alkali added.	Series II. Basicity corrected and acid or alkali added.
2 grams citric acid	11.98	12.41
1 gram citric acid	11.58	12.18
0.5 gram citric acid	10.27	12.07
0.2 gram citric acid	9.69	12.04
Nothing	8.86	11.85
Ammonia equivalent to 0.2 gram citric acid	8.49	11.56
Ammonia equivalent to 0.5 gram citric acid	8.05	10.92
Ammonia equivalent to 1 gram citric acid	7.25	9.66
Ammonia equivalent to 2 grams citric acid	6.20	8.02

Twenty grams of citric acid in 110 cc water dissolve 16.36 per cent (Series I). Twenty-one and four one-hundredths grams of citric acid dissolved in 120 cc water dissolve 16.84 per cent (Series II).

One hundred and ten cubic centimeters ammonia water that would neutralize 20 grams of citric acid dissolve 0.3 per cent (Series I). One hundred and twenty cubic centimeters of ammonia water that would neutralize 20 grams of citric acid and containing 1.04 grams citric acid dissolve 0.96 per cent.

The form of this curve, on the acid side especially, resembles that of precipitated calcium phosphate. The wide divergence of the two lines near the neutral point is rather remarkable. Points of the same actual acidity in the two lines are not in the same horizontal position, but the upper line is always too high. Whether this be due to the larger quantity of citrate present or to the fact that there is 9 per cent more water present in the case of the high results is a question that is now under investigation.

IV.—INFLUENCE OF THE QUANTITY OF SLAG USED.

[Time, five hours. Temperature, 65°. Volume, Series I, 100 cc; Series II, 110 cc.]

Per cent phosphoric acid dissolved.

Quantity of slag used.	Series I. Neutral citrate.	Series II. Basicity corrected.
0.5 gram	12.36	12.41
1 gram	12.37	12.17
2 grams	8.90	11.81
4 grams	3.26	7.37

The curve resembles that for precipitated calcium phosphate, and differs radically from the curves for all other materials that we have examined.

V.—ACTION OF CITRIC ACID ON BASIC SLAG.

Owing to the peculiar action of citric acid on the slag, which has been mentioned above, it was decided to study the action more in detail. The factors investigated were the effect of increased time and temperature on the amount of citric acid neutralized and on the amount of phosphoric acid dissolved. The results of the work appear in the following table:

[Volume, 100 cc of 2 per cent citric acid. Slag used, 1 gram.]

Time of digestion.	Temperature.	Neutralized citric acid.	Phosphoric acid dissolved.
	°*C.*	*Grams.*	*Per cent.*
½ hour	25	0.666	13.28
1 hour	25	.698	14.25
2 hours	25	.734	14.55
3½ hours	25	.736	12.50
5 hours	25	.766	13.20
½ hour	65	.730	12.36
1 hour	65	.780	12.01
2 hours	65	.794	11.04
3½ hours	65	.824	11.28
5 hours	65	.824	7.64
½ hour	(1)	1.124	7.55

[1] Boiling.

The curves show that the amount of citric acid neutralized varies directly with the temperature and the time of digestion. The amount of phosphoric acid remaining in solution at 65° decreases as the time of digestion increases, while at 25° the amount of phosphoric acid remaining in solution increases for a time and then decreases. The direction of the lines seems to indicate a maximum solubility at this temperature of about 15 per cent at the end of one and one-half hours. At 65° the decrease in the amount of phosphoric acid is very marked, and may be due to a solution of the tetrabasic phosphate and its subsequent conversion into tribasic calcium phosphate, which is alleged to be insoluble in dilute citric acid, or it may be due to a conversion into phosphate of iron and alumina. All acid solutions of basic slag give off sulphureted hydrogen, which makes the reactions even more complex. The amount of citric acid neutralized increases more rapidly than is essential to furnish the acid to convert the tetrabasic phosphate into the tribasic form. Thus, in four and one-half hours, between the end of one-half-hour digestion and the end of five-hour digestions, 0.0472 gram of phosphoric acid becomes insoluble. This is equivalent to 0.128 gram of tetrabasic phosphate of lime. To convert 1 molecule of calcium oxid in this amount of tetrabasic phosphate, or 0.0196 gram calcium oxid, into calcium citrate would require 0.048 gram citric acid. The actual amount of citric acid neutralized in the time given was 0.094 gram.

VI.—COMPARISON OF WAGNER'S METHOD WITH THE OFFICIAL METHOD.

This work was done with sample received from Mr. Voigt. The sample was used in the same state of division. It contained some metallic iron. Total $P_2O_5 = 16.81$ Wagner's reagents; 16.80 official reagents.

Series.	Time	Temperature.	Wagner's reagents dissolved.	Official reagents dissolved.	Reverted by difference, Wagner's reagents.	Reverted by difference, official reagents.	Insoluble by difference, Wagner's reagents.	Insoluble by difference, official reagents.	Insoluble, Wagner's reagents.	Insoluble, official reagents.
	Min.	° *C.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct*	*Per ct.*	*Per ct.*	*Per ct.*
No. 1. Wagner's method, acid citrate (5 grams, 500 cc).	30	17½	11.69	11.78	......	......	5.12	5.02	......	......
			11.90	12.13	......	......	4.91	4.67	......	......
			11.55	11.80	......	......	5.26	5.00	......	......
Average	......	......	11.71	11.90	......	......	5.10	4.90	......	......
No. 2. Official citrate, neutral, sp. gr. 1.090 (5 grams, 500 cc).	30	17½	5.86	5.96	......	......	10.95	10.84	......	......
			5.69	6.18	......	......	11.12	10.62	......	......
			6.00	6.18	......	......	10.81	10.62	......	......
Average	......	......	5.85	6.11	......	......	10.96	10.69	......	......
No. 3. Official method, neutral citrate, sp. gr. 1.090 (2 grams, 100 cc).	30	65	......	......	5.22	5.06	......	......	11.59	11.74
			......	......	5.45	5.41	......	......	11.36	11.39
			......	......	5.26	5.11	......	......	11.55	11.69
Average	......	......	......	......	5.31	5.19	......	......	11.50	11.61
No. 3 (*b*). Official citrate, neutral, sp. gr. 1.090 (2 grams, 100 cc).	30	65	5.26	5.00	......	......	11.55	11.80	......	......
			5.30	5.07	......	......	11.51	11.73	......	......
			5.23	5.18	......	......	11.58	11.64	......	......
Average	......	......	5.26	5.08	......	......	11.54	11.72	......	......

The material is not ground finely enough to permit close agreements of duplicates. There seems to be no advantage in Wagner's molybdate or magnesia solution. The filtration and washing of the phosphomolybdate precipitate was very tedious when directly precipitated in the citrate solution. A comparison of set 2 with set 3 shows that a change of volume or quantity of the solvent is of more importance than a change of temperature. If the sample is a fair one a much larger working error than usual must be allowed if the material is to be analyzed in the condition in which it is received.

LABORATORY OF STATE CHEMIST OF INDIANA,
Purdue University, November, 1896.

The **President**. Are there any remarks?

Mr. **Goss**. I would like to say that I consider this work of Professor Huston on the different phosphates as extremely important, not only in the fertilizer work, but also in many other kinds of work—soil work for example—and I for one would be very much pleased to have him publish it. I am interested particularly in this iron and phosphate business.

Mr. **Wheeler**. I am interested particularly in this iron and aluminum phosphate business. What are we as an association going to do? If we find in goods phosphates which contain as high as 38 per cent, in their pure condition, of reverted acid, which is of no use to plants, what is the use of our present method of determining reverted acid? I feel that we shall have to throw the whole thing overboard. There has got to be an entire revolution. I would like to hear from anybody in this association who has had any experience. I understand that in France they claim good results, but it is surprising how inefficient are these phosphates.

Mr. **Huston**. I have had some experience in the field. The fact is, we must be a little careful about our conclusions in regard to phosphates and aluminum and iron in the field, and you must watch the crop a little. I have made some experiments on corn which show phosphate of aluminum to be the most valuable phosphate yet put on. We have done some greenhouse work on potatoes which shows up very well. We have done some other work on roses on which we have good results. In the first place, the question of reverted phosphoric acid in the natural phosphate of aluminum is nonsense. There is no reverted acid there. There is not any of the material once soluble and no longer so. The fact is, that you can dissolve all of that material in ammonium citrate excepting small traces. It is the same old thing; the same old quantity. You will either use not enough volume or fluid or perhaps not enough spirit of ammonia. That appears to be a very important thing so far as the commercial relations of the thing are concerned. It is between the man who sells and the man who buys it. When that material goes in as a phosphate in the ordinary mixed goods containing not a total of 43 to 48 per cent, but a total of only 13 per cent, then you have not a soluble determination in the mixed goods. You are not working on two drams. You are working upon about one-half a dram, from which you would dissolve in the neighborhood of 42 per cent out of 48 of the total. That is, you come near making a 44 determination of what is left. The trouble is not in the mixed goods. I do not think the question is in the form of the agricultural value. The question is the trouble between the man who sells and the man who buys.

Mr. **Wheeler**. I would like to ask the gentleman, in consideration of all his results, if he thinks it is desirable for this association, in the light of what knowledge we now have, to continue the use of ammonium citrate in conducting the determinations as we now do for determining the real worth of commercial fertilizers, particularly where a valuation is placed upon the goods?

Mr. Huston. Yes; I think it is desirable to continue it just as we do, until we have a good reason for changing it. I believe we had better keep what we have. It is the best we know. We will try to get something better if we can.

The **President.** Have you had any experience with Wagner's method?

Mr. Huston. No; I have not used that at all.

Mr. Wheeler. Every member of this association feels this is one of the most valuable pieces of work undertaken by this association in some time, and I hope Professor Huston will publish his results. I feel that we must have something better just so soon as possible, or take some step to eliminate the errors and difficulties which come in. I hope that his work will be published as soon as may be, so we may have that as a basis upon which to start.

Mr. Huston. I referred to the matter of publication last year and stated one reason I did not publish it was because I had no complete analyses of raw phosphates. I asked whether anyone had these, and have not heard from them. I would like a complete analysis of these materials before I publish it. The work is ready to publish as soon as we can get a complete analysis.

The **President.** The association would be much pleased if this work of Professor Huston's were published in a form that would be accessible to us all.

Mr. McDonnell. I have a paper by Mr. Veitch which I would like to present.

THE AMOUNT OF WASHING REQUIRED TO REMOVE THE PHOSPHORIC ACID RENDERED SOLUBLE BY DIGESTION WITH AMMONIUM CITRATE AT 65° C.

By F. P. Veitch.

The amount of washing to be given the insoluble residue from the treatment with ammonium citrate has never been considered by this association, so far as I know, although the subject has been brought to its notice at least twice (Bull. 31, p. 113, and Bull. 35, p. 37, Div. Chem., U. S. Dept. Agr.).

The determination of insoluble phosphoric acid is the determination upon which there is the greatest difference in results among chemists engaged in the fertilizer control. Being desirous of knowing how much this difference may be due to differences in the amounts of wash water used to remove the phosphoric acid rendered soluble by the treatment with ammonium citrate, fifteen samples of fertilizers, representing the commonly occurring goods on our market, were treated as usual until the ammonium citrate was filtered from the residues. The residues were then washed with 100 cc of water at 65° C. These washings were thrown away, the residues further washed until four portions of 100 cc each had passed through the filters; the phosphoric acid was then determined in these four sets of washings, with the following results.

TABLE I.—*Per cent of P_2O_5 removed by washing.*

No.	Fertilizer.	Removed by each 100 cc of wash water.					Insoluble found, washed to 250 cc.
		Second.	Third.	Fourth.	Fifth.	Total.	
1	Dissolved South Carolina rock	0.030	0.025	0.020	0.013	0.088	1.05
2	.....do	.033	.013	.043	.020	.109	.80
3	Dissolved South Carolina rock and potash	.085	.023	.013	.010	.131	.94
4	.....do	.123	.045	.058	.015	.241	2.56
5	Dissolved rock, fish, and potash	.170	.043	.055	.020	.288	1.53
6	Dissolved animal bone	.135	.053	.033	.023	.244	2.65
7	.....do	.088	.038	.048	.025	.199	1.11
8	Animal bone and potash	.100	.063	.040	.023	.226	3.35
9	Bone tankage	.213	.095	.058	.030	.396	6.19
10	Complete fertilizer	.138	.070	.060	.018	.286	2.47
11	.....do	.098	.053	.035	.018	.204	4.42
12	.....do	.250	.078	.063	.043	.434	2.30
13	Complete raw bone base	.180	.055	.025	.045	.305	4.80
14	.....do	.168	.068	.048	.055	.339	6.52
15	.....do	.125	.070	.050	.025	.270	5.34
	Average	.129	.053	.043	.026	.251	....

From the results it appears that an average of 0.251 per cent of phosphoric acid was removed from the samples by the four washings of 100 cc each, over half of which (0.129 per cent) was removed by the second 100 cc of wash water. This shows that practically all the dissolved phosphoric acid was removed in the first 200 cc of wash.

A set of samples was weighed, soluble extracted as usual, treated with ammonium citrate (1.09 sp. gr.) for half an hour at 65° C., filtered, and the residues washed until the filtrate and washings amounted to 250 cc. The flasks were then changed and the residues further washed until 100 cc of water had run through each. The phosphoric acid was determined in these last washings, with the following results:

TABLE II.—*Per cent of P_2O_5 removed by 100 cc water after washing with 150 cc H_2O.*

No.	Fertilizer.	P_2O_5 removed.	No.	Fertilizer.	P_2O_5 removed.
1	Dissolved South Carolina rock	0.030	9	Bone tankage	0.068
2	.....do	.041	10	Complete fertilizer	.040
3	Dissolved South Carolina rock and potash	.041	11	.....do	.075
			12	.....do	.045
4	.....do	.045	13	Complete raw bone base	.063
5	Dissolved rock, fish, and potash	.045	14	.....do	.068
6	Dissolved animal bone	.068	15	.....do	.055
7	.....do	.033		Average	.051
8	Animal bone and potash	.058			

In no case was as much as 0.10 per cent phosphoric acid removed by this extra washing. It will be noticed, however, that the amount is much greater in those containing animal matter.

While the amounts removed even by as prolonged washing as in the first experiment are small, yet differences in the amount of washing the insoluble residue by different analysts may account partly for the differences in results on insolubles. In view of this possibility it might be advisable for the association to set the amount that the insoluble residues shall be washed.

Mr. Wiley. I have a paper here from Mr. Gladding, who has requested me to bring it before the association.

DISCUSSION ON THE ESTIMATION OF PHOSPHORIC ACID.

By T. S. Gladding.

The following work may prove of interest to the members while considering the subject of the Pemberton-Kilgore method of estimating phosphoric acid:

A standard solution of microcosmic salt, 10 grams per liter, was taken for test experiments. A series of determinations, using 25 cc of solution containing 0.250 gram salt was made by two methods. First, the gravimetric method published by myself (Journal Amer. Chem. Soc., Vol. XVII, No. 1), and second, by the volumetric or Pemberton-Kilgore process. The microcosmic salt was the same salt that was used in the work on the gravimetric estimate of P_2O_5 as phosphomolybdate of ammonia, and the results are comparable with those obtained at that time. All results are calculated to percentage results.

Series.	Gravimetric method.		Volumetric method.	
	P_2O_5 found.	Theory.	P_2O_5 found.	Theory.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
1	34.04	34.07	34.10	34.07
2	34.04	34.07	33.90	34.07
3	34.00	34.07	34.10	34.07
4	34.14	34.07	34.10	34.07

A number of comparative tests of fertilizers have also been made.

Series.	P_2O_5 found.	
	Gravimetric method.	Volumetric method.
	Per cent.	*Per cent.*
1	16.68	16.60
2	16.90	16.94
3	1.22	1.19
4	1.11	1.11

It was also found that the yellow salt after drying at 105° C. could be titrated with good results. Although the blue color of the solution was very pronounced, yet by diluting considerably and using a strong, clear light a very sharp reaction could be obtained. The results were as follows:

Series.	P_2O_5 found.	
	By weighing yellow salt.	By titrating the same.
	Per cent.	*Per cent.*
1	16.42	16.32
2	10.11	10.06
3	16.59	16.54
4	3.48	3.38
5	9.25	9.17
6	8.44	8.42
7	15.50	15.46
8	15.30	15.38
9	11.00	11.12
10	0.85	0.88
11	19.48	19.48
12	30.12	30.15
13	30.01	30.00
14	3.24	3.30

These results are very accordant, and prove the uniform composition of the yellow precipitate when precipitated according to directions given in my paper. But it was found that when the molybdate solution was added all at once or suddenly to the solution an excess of precipitate, when dried and weighed, was obtained. The occluded impurity does not seem to interfere with the accuracy of the volumetric process when titrated without previous drying. Its nature has not yet been determined. For gravimetric work a gradual addition of phosphomolybdate solution is essential.

In all the results given above the filtering was done rapidly by means of a pump, and three or four washings of 20 cc each were found sufficient to remove nitric acid from the yellow precipitate. At this point a very important difficulty was experienced. On one occasion several precipitates were given to an assistant to filter and wash until the washings were no longer acid, as per instructions given in method of 1895 meeting. He reported, after some time, that the washings continued acid. An inspection revealed the fact that the precipitate was clearly dissolving in the water employed for washing.

A very thorough examination into the matter seems to show that after all the nitric acid has been removed from the yellow salt a decided solvent action is exerted upon the yellow salt, such solvent action increasing with the amount of the precipitate and with the time of exposure to the water.

Thus, after washing with the pump, as described above, a further washing with 150 cc of distilled water, using about 2 grams of yellow precipitate and taking about an hour for the filtration, dissolved 0.0013 gram P_2O_5; a second treatment with 250 cc water dissolved 0.0025 gram P_2O_5. The yellow salt was now shaken with water for some hours and allowed to stand overnight. One hundred cubic centimeters of clear filtrate was found to contain 0.0063 gram P_2O_5. The same salt was now treated in the same way with 1 per cent nitric acid solution. One hundred cubic centimeters were found to contain 0.003 gram P_2O_5. In like manner 100 cc of 10 per cent KNO_3 solution when saturated in same way were found to contain 0.004 gram P_2O_5. In two cases the water washings came through a perfectly clear solution, yet decidedly yellow in color, and 100 cc of washings contained 0.010 gram P_2O_5. In this work all ammonia vapors were excluded.

I can venture no explanation of these singular experiences, so widely different from the results obtained by Kilgore and others. They show that when the yellow salt is washed too long a decomposition or solution in water seems to take place that may seriously interfere with the accuracy of the results. Either some very strict directions as to washing, limiting the time and amount, or, still better, the finding of some neutral washing liquid that will not exert this solvent action, would seem to be necessary. The trouble which I have experienced is certainly a very remarkable one and requires explanation before the method can be considered as reliable.

Mr. McDONNELL. There is a point right here I do not understand in regard to the use of nitric acid. What is the advantage of using nitric acid as a wash when we must use the same amount of water to wash out the nitric acid? That is a question which has been presented to the association before in considering the washing of this yellow precipitate with ammonium nitrate. It was shown by experiments of several members of this association, by comparing results, that 10 per cent ammonium nitrate and washing with pure water brought practically the same results. If water would reduce the amount of phosphoric acid present, certainly in the former case the same thing would take place.

Mr. WHEELER. I would like to hear from Mr. Kilgore in reply to what has been said.

Mr. KILGORE. The question, as it has occurred to me, in the work I have done upon this method and upon phosphoric acid in general, is that in our regular method we wash with water and do not lose anything, because the washing with water is not carried to a sufficient extent. I consider if the washing were carried to a sufficient extent we would lose. In the washing, after washing with water in the volumetric method, as in this case, it is not carried far enough for this solvent action to take place. As to the use of nitric acid, I feel that it is hardly necessary to say more than I have said in my reports of the last two years. The nitric acid is used to dissolve molybdic acid precipitated. The nitric acid was used to remove that, then the dilute potassium was used to remove the nitric acid, and then the continued washing with water was sufficient to remove—not necessarily to remove this potassium nitrate—any remaining nitric acid that might be there, but not carry the washing to a sufficient extent to dissolve the precipitate. Washing with 250 or 300 or sometimes 400 cc will not affect the precipitate. I consider it perfectly safe to wash with 300 cc and usually with 400, but I would not hesitate to wash with 300.

Mr. FREAR. I would like to ask a question. Have you proven to your own satisfaction that after washing with 250 cc of water you get a solution which is not acid?

Mr. KILGORE. You will get a solution which is very slightly acid. After washing with potassium nitrate and some water there will be a very slight acidity. I reported in last year's proceedings, you will notice, that the acidity was not enough to affect results. I combined the washings after washing first with nitric acid and the potassium nitrate, and I then washed a number of precipitates and made these in triplicate; used several and then evaporated them and determined the phosphoric acid, and I figured that and found it only amounted, where I used a liter of water, to 0.200 per cent. It is only very slightly acid.

Mr. FREAR. That was my general recollection of what Mr. Kilgore said, and the question came strongly to me whether it would not be wise to so modify the language of the method that so experienced a chemist as Mr. Gladding would not be misled by the language of the method. Say "until the filtrate is no longer acid." It certainly would be misleading as it is. Would it not be sufficient to say, "wash with no more than 250 cc of water?"

Mr. KILGORE. That was practically the recommendation I made last year.

Mr. FREAR. I was going to move that the consideration of this wording be referred to the committee on recommendations when they report.

Mr. WILEY. I would like to present a paper relating to phosphatic fertilizers.

THE MECHANICAL ANALYSIS OF BASIC PHOSPHATIC SLAGS.

By H. W. Wiley.

Before discussing the subject-matter of the paper which I now present I think it desirable to give a short sketch of the earlier literature relating to basic slags and the methods of their valuation.

In 1882, while examining some very finely ground bone in the laboratory at Purdue University, Lafayette, Ind., I noticed a marked solubility of the phosphoric acid therein in neutral citrate of ammonia. At that time Mr. H. A. Huston, who was a student in my laboratory, was directed to make some investigations of this phenomenon, and the results of his work were incorporated in his thesis for graduation, and the data were published in the proceedings of the agricultural college of Indiana, Purdue University, for the year 1882.

In 1886 Jensch noticed that when lime and tricalcium phosphate were ignited together and the resulting mass pulverized, both citric acid and neutral ammonium citrate would extract phosphoric acid from the powder. (Berichte, vol. 19, p. 3093.)

In 1887 I published in Agricultural Science (March number) an article on the use of phosphorus contained in iron ores as a fertilizing material after the conversion of the ores into iron or steel.

In 1889 I received from the Pottstown Steel Works a sample of phosphatic slag which was sent me under the name of cinder. The superior merits of basic phosphatic slags as a fertilizer led me to believe that they might be largely soluble in neutral citrate solution. I therefore had this sample examined by Messrs. McElroy and Krug with that object in view. It was found to contain 20.20 per cent total phosphoric acid, of which 12.25 per cent were soluble in neutral ammonium citrate, the official solution used for the analysis of phosphatic fertilizers. An account of this property was published in the Journal of Analytical Chemistry, October, 1889. In this paper it is stated: "From the above results it is seen that in the phosphate slag we have a form of phosphoric acid equivalent in value to a first-class superphosphate."

Petermann, in 1889, called attention to the fact that the calcium phosphatic limestone gives up phosphoric acid to a citrate solution. (Chemisches Central-Blatt, 1889, vol. 2, p. 1036.)

In 1890 Jensch proposed the use of citric acid for the separation of tetra from tricalcium phosphate.[1]

In 1892 Foerster published the statement that tetracalcium phosphate is easily soluble in ammonium citrate solution.[2]

Wagner proposed a special ammonium citrate solution having an excess of citric acid as a solvent for the tetracalcium phosphate in basic slags, and published an account of it in 1893.[3]

Since then the literature on this subject is very extensive, and it would be useless to attempt to cite the papers which have been published. It appears from a study of the literature that the first published account of the application of ammonium citrate as a method of valuing the availability of phosphatic slag was made from this laboratory in the paper published in the Journal of Analytical Chemistry above noted. For some reason, however, the method itself is universally known as the Wagner process.

Experience has shown that the official method of determining available phosphoric acid applicable to the reverted phosphoric acid in superphosphates is of little value when applied to phosphatic slags. The composition of phosphatic slags has been previously described by Krug and myself.[4] It is evident that the tetrabasic lime phosphate is less stable than the tricalcium phosphate, and hence the phosphoric acid which it contains is more readily given up to the growing plant. When a basic phosphatic slag is treated by neutral ammonium citrate in the regular official manner, the quantity of phosphoric acid which passes into solution is far less than the available content of phosphoric acid as indicated by the effect of the fertilizer upon a growing crop. For this reason other methods of determining available phosphoric acid have been proposed, and the one now in use is known as the Wagner process, in which a strongly acid ammonium citrate solution is used as a solvent.[1] The method of solution employed is a purely arbitrary one, but gives results comparable to the effects produced in the field.

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[1] Zeitschrift für Angewandte Chemie, 1890, p. 504.

[2] Zeitschrift für Angewandte Chemie, 1892, No. 113.

[3] Chemiker Zeitung, vol. 13, p. 1153.

[4] Jour. Anal. and Applied Chemistry, vol. 5, p. 685.

The action of this solvent on phosphatic slags is very different for different samples. In some cases almost the whole of the sample is composed of pure tetracalcium phosphate, and in these instances the solvent action of the reagent is very high. In other cases the sample may contain tricalcium phosphate, particles of siliceous slags, and also of iron and steel. In these instances a low solvent action is noticed. It therefore has seemed desirable to supplement the chemical analysis of the slags with a mechanical separation. For particles of one-tenth of a millimeter in diameter, and above, this separation is easily effected in a series of sieves, the finer sieves being made of bolting cloth. It is evident that a further separation of the fine particles can not be secured by water, by reason of the action of this reagent upon the free lime which the slag contains. About four years ago I made some experiments looking to the substitution of alcohol in the place of water in the mechanical analysis of soils. The preliminary experiments succeeded so well that it was deemed advisable to use alcohol for securing the separation of the finer particles of the slag. The separations were made for me by Mr. C. C. Moore, of the laboratory staff. The method of procedure is as follows:

From 20 to 50 grams of the slag are placed in a shaking bottle and vigorously agitated for a few minutes on a milk-shake machine. This treatment serves to break up all the flocculates the sample may contain. The sample is placed in beakers entirely similar to those which are used in the mechanical separation of the soils by the subsidence method. At first it was only desired to secure two series of separates of the fine particles, and these were obtained by an arbitrary time standard of subsidence. All the particles which remained in suspension in a column of 15 centimeters of alcohol for five minutes were collected together and marked as separate No. 5. When all the particles which thus remained in suspension had been removed another separation was made, consisting of those particles remaining in suspension in like conditions for two minutes and a half. This portion of the sample was collected and was designated as separate No. 4. The remaining portion of the sample was freed of alcohol and separated into three portions, by sifting through two sieves made of bolting cloth with meshes one-tenth and one-quarter of a millimeter, respectively. All that portion passing through the one-tenth millimeter mesh is designated as separate No. 3. The portion passing the quarter millimeter mesh but not passing the tenth millimeter mesh is designated as separate No. 2. The portion not passing through the quarter millimeter mesh is designated as separate No. 1. The remarkably uniform size of these separates is shown by photographs published in the Journal of the American Chemical Society, Vol. 19, p. 19. By an inspection of separate No. 5 it is seen that it could be easily divided, and another and finer portion, by means of a ten-minutes' subsidence in alcohol, be secured.

The alcohol used for the separation is of 90 per cent strength.

The original sample and the separates were subjected to a chemical analysis, conducted for me by Mr. E. G. Runyan, of the laboratory staff. The analytical work was confined to a determination of the total phosphoric acid and that soluble in the Wagner reagent. The data obtained follow:

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[1] Wiley's Agricultural Analysis, vol. 2, p. 80.

Substance.	Original sample.	Separate No. 1.	Separate No. 2.	Separate No. 3.	Separate No. 4.	Separate No. 5.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Total P_2O_5	16.54	13.91	16.14	16.71	18.21	18.16
Citrate soluble P_2O_5	11.67	6.24	10.85	12.21	13.65	14.91
Proportion of original sample	....	12.00	33.00	26.00	8.00	21.00

From the above analyses it is seen that the separates 4 and 5 contain not only the highest total quantity of phosphoric acid, but also the highest available acid. It is seen that there is a regular progression in the richness and availability of the sample from the coarsest to the finest parts. The relative proportions of the different separates to the whole are shown in the table. The data lead to the inference that it may be advantageous to the manufacturer of basic slags to secure at least a partial separation in some such manner as indicated, for the purpose of being able to place on the market a more concentrated and available fertilizing material. The annual product of basic phosphate slags now amounts to about 1,500,000 tons and the output is rapidly increasing. Up to the present time American analysts have not had occasion to examine many samples of phosphatic slags, but it is certain, in the near future, that the consumption of this material in the United States will rapidly increase. It is important, therefore, that investigations be made looking to the best methods of chemical and mechanical analyses.

The PRESIDENT. Are there any more papers on the subject of phosphoric acid? Is there any further discussion of the subject? If not, since the hour for adjournment is near at hand, we will now take a recess until 2 o'clock p. m.

SATURDAY—AFTERNOON SESSION.

The meeting was called to order by the president at 2 o'clock. The regular order was the report on soil and ash analysis, which was presented by Mr. Goss.

REPORT ON SOILS AND ASH.

By ARTHUR GOSS, *Reporter*, and W. G. BROWN, *Associate Reporter*.

As a preliminary step in the soil work this year, a circular letter was sent to the chemists of the different experiment stations inquiring what subjects it was thought best to take up. From the replies received, and in accordance with the views of the reporters, it was thought best to limit the chemical work on soils to a further study of methods for determining the availability of phosphoric acid and potash. As a considerable number of chemists also expressed a desire to have a study of the physical properties of soils included, upon request, Prof. Milton Whitney, Chief of the Division of Agricultural Soils, United States Department of Agriculture, kindly consented to furnish the working directions.

Much time was consumed in searching for suitable samples. In this connection, a circular letter was sent to the chemists and agriculturists of the different stations asking concerning samples of soils which had been proven deficient in available phosphoric acid and potash by a number of years' scientific field-fertilizer tests. After a considerable amount of correspondence, typical potash samples were secured, through the kindness of Mr. A. M. Peter, from the Kentucky Experiment Station farm, and a soil proven deficient in available phosphoric acid from Massachusetts, through the kindness of Mr. William P. Brooks, of the Hatch Experiment Station. As a sample containing plenty of available phosphoric acid, one was taken from a field on the New Mexico Experiment Station farm. After having received the results of the work on these soils, the reporter feels sure that more typical samples could not well have been found for the points under consideration.

The following descriptions of the samples and working directions were sent to the chemists who had consented to cooperate:

DIRECTIONS FOR WORK ON THE A. O. A. C. SOIL AND ASH SAMPLES FOR 1896.

DESCRIPTION OF THE SAMPLES.

Soil sample No. 1 is from Acre P, plat 2, of the Kentucky Experiment Station farm. (See Kentucky bulletins.) It has been cultivated for a number of years without the addition of any fertilizer, and will not, at present, produce a large crop. From several years' fertilizer tests on adjacent plats, it has been shown that in all probability the trouble is lack of available potash.

Soil sample No. 2 is also from the Kentucky Experiment Station farm. This soil has not been under cultivation, at least for a number of years, and in all probability contains sufficient available potash to produce several good crops.

Soil sample No. 3 is from the farm of Mr. Dole, of Shelburne, Mass. The results of fertilizer tests on this soil have been reported in Bulletins 14, 18, etc., of the Hatch Experiment Station. It has usually responded to phosphatic fertilizers during several years' tests, and in all probability does not, at present, contain sufficient available phosphoric acid to produce a large crop.

Soil sample No. 4 is from the New Mexico Experiment Station farm in the Rio Grande Valley. Judging from the crops produced, it contains a good supply of available phosphoric acid. It is probably about an average soil in the amount of total phosphoric acid contained.

Sample No. 2 probably contains an unusually large amount of available phosphoric acid, and No. 4 an unusually large amount of available potash.

The ash sample is from New Mexico grown alfalfa, or lucern.

In the directions given below, unless otherwise stated, references are to the "Methods of analysis adopted by the A. O. A. C., September, 1895," published as Bulletin No. 46 of the Chemical Division, United States Department of Agriculture.

WORKING DIRECTIONS FOR THE ASH.

Analyze by the association method, page 44. The sample is ready for analysis.

WORKING DIRECTIONS FOR THE SOILS.

The samples are sifted ready for analysis. Samples 1 and 2 are to be worked for potash only, and samples 3 and 4 for phosphoric acid only, except No. 4, in which both potash and phosphoric acid are to be determined, as outlined below in No. 7. All results are to be calculated to the water-free basis.

All reagents used should be tested by running blank determinations with at least the quantities used in the regular determinations.

1. *Moisture.*

Determined by the association method, page 38.

2. *Treatment with citric acid.*

Prepare a one-fifth normal citric-acid solution by dissolving 14 grams of the crystallized acid in each liter of water used and bringing to exact strength by titrating against carbonate-free KOH, using phenolphtalein as an indicator. Transfer 100 grams of each of the samples to half gallon, salt-mouth, glass-stoppered bottles, or other similar vessels; pour on each exactly 1 liter of N/5 citric acid, place in a large water bath (a metal washtub will do), and keep at the temperature of 40° for exactly five hours, shaking at frequent intervals. At the end of the digestion shake contents of bottle well and pour quickly upon a large, dry, ribbed filter of two thicknesses of paper and of sufficient size to receive the entire contents of the bottle. The filtrate is to be received in a dry vessel and the solution poured back through the paper until it is entirely free from soil particles. Evaporate 500 cc of the filtrate, corresponding to 50 grams of soil, to a small volume in a porcelain dish, transfer to a platinum dish, bring to dryness or nearly so on the water bath, finish drying in the air bath at a higher temperature, and burn out the organic matter at as low a heat as possible, in order to avoid volatilizing potash. Transfer the residue to a small porcelain dish, cover, and add about 20 cc of concentrated HCl.

When effervescence has ceased remove the cover and evaporate to dryness on the water bath; finish, if necessary, in the air bath at a slightly higher temperature. Take up the residue with 2 or 3 cc of strong HCl and a little water, digest on the water bath until the iron compounds have been dissolved, filter off the carbon, silica, etc., wash with hot water, and determine potash or phosphoric acid in the filtrate (Filtrate A), as follows:

(A) K_2O. *To be determined in samples 1 and 2 only.*

Dilute Filtrate A to about 100 cc, heat to boiling, precipitate with ammonia and ammonium oxalate in slight excess, filter, wash thoroughly with hot water, evaporate filtrate to dryness in a plantinum dish, add 1 cc of 1 to 1 H_2SO_4, and expel ammonium salts by ignition. Take up residue with water and a few drops of ammonium-free HCl, filter if necessary, add 2 cc of the usual platinum-chlorid solution, and finish the determination as under the Lindo-Gladding method, page 3.

If preferred, the potash may be determined directly in Filtrate A by the following modification of the Tatlock method, as recommended by Dyer (see Journal of the London Chemical Society, March, 1894): "To Filtrate A in a platinum dish add 2 cc of platinum-chlorid solution, evaporate to dryness, take up with 80 per cent alcohol, filter, wash with alcohol, ammonium-chlorid solution, etc., and proceed as under the Lindo-Gladding method. This method is much quicker than the usual one and has been found to give good results. It is to be observed, however, that the HCl used in dissolving the residue after ignition must be free from ammonium salts." In reporting results please state which method was used.

(B) P_2O_5. *To be determined only in samples 3 and 4.*

Add ammonia to Filtrate A to alkaline reaction, then add nitric acid to acid reaction and evaporate to about 50 cc. Add 10 grams of ammonium nitrate, heat to 80°, add at least 50 cc of recently prepared molybdate solution, allow to stand in a warm place for 12 hours, filter off precipitate, wash with ammonium-nitrate solution acidulated with nitric acid, dissolve precipitate in warm ammonia and precipitate with magnesia solution in the usual manner.

If preferred, the P_2O_5 may be rapidly precipitated after neutralizing with ammonia, acidifying with nitric acid, and adding ammonium nitrate, as recommended in the proceedings of the Eleventh Annual Convention of the A. O. A. C., page 58. In this case the solution should be diluted (100 cc) and a freshly prepared molybdate solution used.

3. *Treatment with ammonium citrate.*

Treat 100 grams of each sample exactly as under citric acid, No. 2, with 1 liter of neutral ammonium citrate solution, containing 100 cc of the usual fertilizer citrate solution, prepared as under "Optional method," page 11.

4. *Treatment with oxalic acid.*

Prepare a one-fifth normal solution of oxalic acid by dissolving 12.6 grams of the crystals in each liter of water used, and bringing to exact strength by titrating against standard carbonate-free KOH, using phenolphtalein as an indicator. Treat 100 grams of each sample with 1 liter of this solution exactly as under No. 2.

5. *Treatment with ammonium oxalate.*

One hundred grams of each sample are to be treated with 1 liter of ammonium-oxalate solution containing 16 grams of the crystals, exactly as under citric acid.

6. *Treatment with hydrochloric acid.*

Digest 100 grams of each sample with 1 liter of fifth normal HCl for five hours, at 40°, as before. Filter and evaporate 500 cc of the filtrate to dryness in a porcelain dish; after adding a few cubic centimeters of nitric acid to oxidize organic matter, continue the drying in the air bath until complete dryness is reached, take up with water and a few cubic centimeters of HCl, filter and determine K_2O or P_2O_5 in the filtrate (Filtrate A), as given under No. 2.

7. *Effect of varying the amount of solvent.*

Treat amounts of 200 grams each of sample 4 with 1, 2, 3, 4, and 5 liters of fifth normal citric acid, and determine both K_2O and P_2O_5 in each filtrate, as under No. 2. Solutions corresponding to 50 grams of soil are to be precipitated in each case.

8. *Physical examination of the soils.*

For working directions for the physical examination of the soil samples, reference will be made later to a bulletin by Professor Whitney, of the Division of Agricultural Soils, United States Department of Agriculture. This bulletin is now in press.

Any other results on the above, or other soils of known agricultural properties, will be thankfully received.

In the preparation of the above directions free reference has been made to the directions of the reporter of last year.

Use Bulletin No. 4, of the Division of Agricultural Soils, United States Department of Agriculture, on Methods for the Mechanical Analysis of Soils, by Prof. Milton Whitney, for the working directions. Begin with sample No. 1 and page 9 of the bulletin and do as much as you can find time to accomplish.

TABLE No. 1.—*Soil samples.*

Analyst.	Sample No. 1.							Sample No. 2.						
	Moisture, association method.	K_2O. 100 grams of soil and 1 liter of solvent used. Water-free basis.						Moisture, association method.	K_2O. 100 grams of soil and 1 liter of solvent used. Water-free basis.					
		N/5 HCl.	N/5 $CaCl_2$.	N, 5 citric acid.	Citrate solution, diluted 1 in 10.	N/5 oxalic acid.	Am. oxalate, 16 grs. per liter.		N/5 HCl.	N/5 $CaCl_2$.	N/5 citric acid.	Citrate solution, diluted 1 in 10.	N/5 oxalic acid.	Am. oxalate, 16 grs. per liter.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
John Thompson, South Carolina	2.25	0.011	......	0.006	0.006	0.005	0.016	3.01	0.024	......	0.014	0.022	0.014	0.030
C. C. Moore, United States Department of Agriculture	1.72	.011	......	.006	.005	.011	.011	2.05	.033	......	.023	.020	.038	.016
R. F. Hare, New Mexico	1.71	.013	......	.008	.010	.010	.011	1.95	.022	......	.031	.022	.024	.034
Arthur Goss, New Mexico	1.83	.012	{0.006 .004}	.007	.008	.011	.009	2.10	.024	{0.015 .015}	.020	.020	.022	.021
Average	1.88	.012	.005	.007	.007	.009	.012	2.28	.026	.015	.022	.021	.024	.025

TABLE No. 2.—*Soil samples.*

Analyst.	Sample No. 3.							
	Moisture, association method.	Total P_2O_5, Goss method.	P_2O_5. 100 grams of soil and 1 liter of soil used. Water-free basis.					
			N/5 HCl.	N/5 $CaCl_2$.	N/5 citric acid.	Citrate solution diluted 1 in 10.	N/5 oxalic acid.	Am. oxalate, 16 grs. per liter.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
John Thompson, South Carolina	2.26	....	0.020	....	0.034	0.026	0.080	0.012
C. C. Moore, United States Department of Agriculture	....	....	....	....	....	....	....	....
R. F. Hare, New Mexico	1.59	0.22	.019	....	.032	.018	.096	.010
Arthur Goss, New Mexico	1.67	.21	.019	0	[1].023	.019	.097	.010
Average	1.84	.22	.019	0	.033	.021	.091	.011

Analyst.	Sample No. 4.											
	Moisture, association method.	Total P_2O_5, Goss method.	P_2O_5. 100 grams of soil and 1 liter of solvent used. Water-free basis.								K_2O.	
			N/5 HCl.	N/5 HCl corrected for neutralization.	N/5 $CaCl_2$.	N/5 citric acid.	N/5 citric acid corrected for neutralization.	Citrate solution diluted 1 in 10.	N/5 oxalic acid.	Am. oxalate, 16 grs. per liter.	N/5 HCl corrected for neutralization.	N/5 $CaCl_2$.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
John Thompson, South Carolina	5.61	......	0.051	......	......	0.025	......	[1]0.024	0.083	0.013	......	......
C. C. Moore, United States Department of Agriculture	3.26	......	.046	......	......	.027	......	.004	.076	.009	......	......
R. F. Hare, New Mexico	4.26	0.15	.049	......	......	.025	......	.005	.080	.008	......	......
Arthur Goss, New Mexico	4.65	.13	.051	0.081	0	.024	0.033	.004	.088	.009	0.090	0.051
Average	4.45	.14	.049	.081	0	.025	.033	.004	.083	.010	.090	.051

[1] Not included in the average.

TABLE No. 3.—*Soil samples.*

Analyst.	Sample No. 4. Different amounts of same solvent. 200 grams soil.									
	K_2O. Water-free basis.					P_2O_5. Water-free basis.				
	1 liter N/5 citric.	2 liters N/5 citric.	3 liters N/5 citric.	4 liters N/5 citric.	5 liters N/5 citric.	1 liter N/5 citric.	2 liters N/5 citric.	3 liters N/5 citric.	4 liters N/5 citric.	5 liters N/5 citric.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
John Thompson, South Carolina	0.020	0.041	0.058	0.069	....	0.004	0.028	0.031	0.035	......
C. C. Moore, United States Department of Agriculture.	.032	.055	.069	.077	0.106	.004	.023	.030	.035	0.046
R. F. Hare, New Mexico	.025	.051	.066	.074	.085	.004	.027	.028	.036	.041
Average	.026	.049	.064	.073	.095	.004	.026	.030	.035	.043

TABLE No. 4.—*Alfalfa ash.*

Substance.	By C.C Moore, U. S. Department of Agriculture.	By A. M. Holt, New Mexico.	Substance.	By C.C. Moore, U. S. Department of Agriculture.	By A. M. Holt, New Mexico.
	Per cent.	*Per cent.*		*Per cent.*	*Per cent.*
Soluble SiO_2	3.76	3.72	SO_3	4.79	4.58
Insoluble SiO_2 (sand)	6.23	5.72	CO_4	18.10	17.94
Total SiO_2	9.99	9.44	Cl	3.80	4.21
K_2O	21.20	21.27	Carbon	9.54	10.34
Na_2O	2.95	2.83	Moisture	.61	.76
CaO	20.45	20.32	Total	100.87	....
MgO	3.34	3.39	O equivalent of Cl	.86	....
Mn_3O_4	.12	.05			
Te_2O_3, Al_2O_3	2.71	....	Corrected total	100.01	....
P_2O_5	3.28	3.27			

THE RESULTS.

It would seem that the soil reporter has, as usual, been guilty of asking for a larger amount of work than many men so busy as the chemists of the agricultural experiment stations could well find time to undertake. It is probably largely for this reason that no results have been received on the physical investigation of the soils and but few on the chemical soil and ash work.

The results of the ash work are given in table 4. While the reporter has been aware that the method of analysis for the ash is badly in need of revision in some respects, owing to lack of time nothing has been attempted in that connection this year.

The results on the soils are given in tables 1, 2, and 3. While few in number, some very interesting points are brought out. The reporter feels not a little encouraged in believing that we may at last have methods at hand by which it may be possible to tell at least the difference between a soil containing little available potash or phosphoric acid and one containing a considerable amount of those substances. Much more work will of course be necessary, however, before we can form any very definite conclusion in regard to these methods.

The agreement of results this year is quite as good as could be expected, and the reporter wishes to take this opportunity to thank those who have cooperated in the work.

Of the solvents tried the organic acids may, I think, after two years' trial by the association, be dismissed at once as unsuited for the determination of available phosphoric acid and potash in soils, and especially so far as the P_2O_5 is concerned. While all the solvents have shown a marked difference between the two potash soils, and that in accordance with the evidence furnished by the field tests, the organic acids are no better in that respect than hydrochloric acid, and especially calcium chlorid, and besides, owing to the large amount of organic matter to be burned out, are much more difficult to work, and consequently more liable to yield discordant results.

In the case of phosphoric acid, the organic acids and salts have given utterly conflicting and misleading results. Take the case of the diluted fertilizer citrate solution, for example. In the case of soil No. 4, which experience in the field has proven contains a sufficient supply of available phosphoric acid, 0.004 per cent is secured as the average of three closely agreeing results, while in the case of soil No. 3, which has been proven deficient in available phosphoric acid, more than five times as much is gotten. The soil reporter would be very much obliged if the fertilizer chemists would kindly explain this point.

In the case of citric acid, which has also been largely recommended for this purpose, the results are also the opposite of experience in the field, and oxalic acid is little or no better.

In the case of N/5 hydrochloric acid, however, we have a solvent which, in the case of these soils, gave closely agreeing results that were entirely in accordance with the field tests. This solvent, furthermore, is very much easier to work with than the organic acids.

The two phosphoric acid soils well illustrate one point that has been overlooked by some of the investigators in soil analysis, though mentioned by a few, and that is the necessity of correcting for the neutralization of the solvent by carbonate of lime and other alkaline material when an acid solvent is used. No. 4 contains a large amount of lime (about 4 per cent), while No. 3 contains very little of that element. Hence, in the case of acid solvents, before the digestion is fairly started, No. 4 is being acted upon by a very weak solvent, whereas in the case of No. 3 it is practically full strength.

In the following table is given the dilution of hydrochloric and citric acids, in the case of these soils, as determined by titrating the filtrate at the end of the digestion against standard potassium hydrate solution, using phenol as an indicator:

TABLE 5.—*Showing neutralization of the solvent, due to the presence of lime carbonate and other alkaline material in the soil.*

Reagent.	HCl used as a solvent.				Citric acid used as a solvent.			
	1	2	3	4	1	2	3	4
Strength of acid at beginning in terms of normal acid	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200
Strength of acid at end of 5 hours' digestion in terms of normal acid	.191	.182	.197	.050	.175	.170	.195	.062
Per cent of solvent neutralized	4.5	9	1.5	75	12.5	15	2.5	69

By referring to table 5 it will be noticed that in the case of No. 4, 75 per cent of the acid were neutralized when using HCl, while in the case of No. 3 but 1.5 per cent were neutralized, and in the case of citric acid the difference is almost as great. The difference in the case of the two potash soils is much less.

The results secured in the case of hydrochloric and citric acids, after making the acid of sufficient strength to allow for this neutralization, are shown in table 2. While the citric dissolved considerably more from soil No. 4 after being corrected, the results are still in no way comparable with the field tests. In the case of HCl, however, we have a solvent which, after correction, dissolved more than four times as much phosphoric acid from No. 4 as from No. 3, thus agreeing exactly with the field experience, notwithstanding the fact that No. 3 contained nearly twice as much total as No. 4. The fact that in the case of these two soils the one deficient in available phosphoric acid contains more total than the one with a good supply of available again illustrates the fact that, as is already well known to anyone who has done any considerable amount of soil work, the determination of the total phosphoric acid alone may give very misleading results concerning the amount of that substance available. The determination of the total, however, when taken in connection with the amount dissolved by dilute HCl, would seem in the case of these two soils, at least, to furnish unmistakable evidence of the more available condition of the phosphoric acid in No. 4.

It has been urged by some that a strong mineral acid, such as HCl, should not be used as a solvent for available plant food, on account of being more energetic in its action than the acids at the command of plants. As has previously been pointed out by myself and others, however, this objection will not hold in the case of at least one of the organic acids. By referring to table 2 it will be seen that oxalic acid dissolved several times as much phosphoric acid from both the phosphoric acid soils as hydrochloric acid of exactly the same strength. Oxalic acid seems to have a very strong solvent effect upon the iron compounds in the soil, and it has been my experience that the phosphoric acid usually comes into solution in connection with the iron.

Upon observing the decided increase in amount of phosphoric acid dissolved from No. 4, after correcting for the neutralization of the solvent, in the case of HCl, I was led to think that a part of the increase might be due to the solvent effect of the calcium chlorid formed. Upon trying a N/5 solution of that substance, however, it was found to have practically no solvent effect for the phosphoric acid, thus eliminating what might have been a very perplexing factor in the case. This solvent also took into solution very little of either iron, silica, or organic matter.

From the above it would seem perfectly evident that in the case of phosphoric acid, where HCl is used as the solvent, especially in the case of soils like No's. 3 and 4, differing largely in lime content, a correction should be made for the neutralization of the acid.

While calcium chlorid has practically no solvent effect for phosphoric acid, it has a decided solvent effect for potash, as will be seen by examining Table No. 1. I consider this substance to be the most promising solvent for available potash that I have ever tried. By bringing into solution very little iron, silica, or humus the analysis is not complicated by the presence of large amounts of those substances as is usually the case with other solvents. The solvent effect of calcium chlorid is probably due to the well-known trade of bases in soil absorption, thus relieving the potash in a state of loose combination, or the presumably available, and not disturbing that locked up with the silicates. It will be observed, by referring to table 1, that calcium chlorid dissolved three times as much potash from the soil containing a good supply of available potash as from the soil known to be deficient in that substance. It is also interesting to note that in the case of soil No. 4, which is known to contain a large amount of available potash, calcium colorid dissolved more than twelve times as much as in the case of soil No. 1.

It seems quite certain that such conditions as time and temperature of solution and strength and amount of solvent to be used must be definitely fixed if concordant results are to be expected. The plan of digesting a certain amount of soil for a week, more or less, at any temperature that may happen to prevail in the laboratory at the time, as has been practiced by some soil analysts, will not answer. Table No. 3 shows very conclusively the necessity of definitely fixing the relation between the amount of soil and solvent. So long as this proportion remains the same, however, the results will be the same whether large or small quantities be used. This is shown in Table No. 2 by referring to the per cent of phosphoric acid dissolved in No. 4 by treating 100 grams with 1 liter of citric acid, as compared with the results in Table No. 3 from treating 200 grams of the same soil with 2 liters of the same solvent. In several trials by myself with different solvents the same result has also been reached.

METHODS OF ANALYSIS.

The reporter believes that the principal end to be sought in the agricultural chemical analysis of a soil is to secure data by which to decide, if possible, in regard to its plant-producing power. Now, it has been abundantly demonstrated that most soils contain an abundance of all the elements of plant food except phosphoric acid, potash, and nitrogen. It is on this assumption that our present system of soil fertilization rests. That this assumption is usually correct is proven by the large amount of money invested in the fertilizer industry and the unmistakably advantageous results constantly obtained by the use of fertilizers. Now, it seems to me that our practical analysis of the soil should be along these lines, especially in the East. If we can tell with reasonable certainty the amount and availability of the phosphoric acid, potash, and nitrogen in soils we have accomplished the principal thing that is at present demanded of the soil analyst.

It is interesting, to be sure, from a scientific point of view, to know the amount of iron, manganese, silica, etc., in a soil, and these things doubtless have some bearing on the question of plant production; but, owing to the time required to make such determinations and the uncertainty of the indications furnished, I do not believe that in practical work we can afford to spend time with them, at least not until we have more definite knowledge concerning the determinations of the three essential elements.

It seems to me that the thing to be done at present is to attempt to work up good, reliable methods for the determination of total phosphoric acid, total nitrogen, and either total potash or that dissolved in some strong solvent which shall give us a definite stopping point; and besides this, methods for determining the amounts of these substances that are soluble in weak solvents which shall, when taken in connection with the determinations of the totals, furnish reliable indications concerning the availability of those substances.

In the sulphuric acid method for phosphoric acid recently adopted by the association I believe we have a thoroughly reliable method for the determination of total phosphoric acid, and in the modified Kjeldahl method I believe we have an equally reliable method for total nitrogen. I do not believe that we have at present any method equally reliable and of sufficient brevity for practical purposes for the determination of potash soluble in a strong solvent; at least the discordant results reported to the association in the past have indicated this. The sulphuric acid method tried last year, however, gave results fully as good as by the other methods tried, and has the advantage of being a direct method and much quicker than the others.

In the hydrochloric acid and calcium chlorid methods outlined below we have methods for available phosphoric acid and potash which have worked well, and given results strictly in accordance with the field tests with this year's samples, and which I think should certainly be further tried.

For available nitrogen the association has at present no method, although Dr. Hilgard has recently proposed one for that purpose which I think should be tested.

RECOMMENDATIONS.

In accordance with the foregoing the reporter recommends—

1. That the complete analysis of a strong acid solution of the soil as given last year and in preceding years be stricken out of the official methods of the association.

2. That the N/5 HCl method for available phosphoric acid, as given below, be further tried by the association.

3. That the calcium chlorid method given below be further tested by the association as a method for available potash.

4. That the Kjeldahl method, as revised by the reporter, be adopted as the official method for total nitrogen.

The reporter fully realizes that the recommendations offered above are sweeping in character and involve a change in the entire system of soil analysis, but he believes that past experience and present needs fully justify such a change. We can certainly do no worse than at present, and I believe can, by placing soil analysis on a more practical basis, do very much better.

AVAILABLE PHOSPHORIC ACID.

1. Preliminary treatment to determine the neutralization of the solvent.

Weigh out 20 grams of soil, transfer to a dry flask of 400 or 500 cc capacity, add 200 cc of exactly fifth normal HCl, stop flask with a perforated rubber stopper carrying a glass tube about 2 feet long, and digest in a water bath for exactly five hours at exactly 40° C., shaking contents at frequent intervals. At the end of the digestion, filter the solution and titrate against a standard carbonate-free KOH solution, using phenolphtalein as an indicator.

2. Weigh out 100 grams of soil, transfer to a dry half-gallon salt mouth glass-stoppered bottle or other similar vessel and add exactly 1 liter of HCl of fifth normal strength plus the amount of acid neutralized by 100 grams of the soil as determined by the preliminary treatment. Immerse bottle at least to the top of the solution in a large water bath (a metal washtub is excellent), kept at a temperature of exactly 40° C., and digest for exactly five hours, shaking at frequent intervals. Remove bottle from bath, shake up contents and pour on a large dry-ribbed filter of two thicknesses of paper. The paper and funnel should be large enough to receive the entire solution; an 8-inch funnel, with paper to match, is about right. The first portion of the filtrate is to be used to rinse out the receiving vessel if the same or the funnel be wet. The solution must be poured back through the paper until entirely free from soil particles. Transfer 500 cc of the filtrate to a porcelain dish, add 2 or 3 cc of nitric acid, and evaporate to dryness, first over the lamp and finally over the water bath, moisten the residue with HCl, add hot water and digest over the water bath until all iron compounds are dissolved. Filter off the silica, receiving the filtrate in a flask of 400 or 500 cc capacity, wash with hot water, dilute the filtrate to about 100 cc if not already to that volume, add ammonia until a permanent precipitate forms, then nitric acid until the precipitate is dissolved, add 20 cc of ammonium nitrate solution containing 15 grams of the salt, heat to 80°, precipitate with 75 cc of recently prepared molybdate solution, and continue the determination exactly as under "Total acid soluble phosphoric acid," Goss method. (See methods of analysis adopted by the A. O. A. C. November, 1896.)

Reagents.—The HCl solvent is prepared by titrating against standard carbonate-free KOH, using phenolphtalein as an indicator. Phenol should be used as the indicator, as it seems to give the best results when titrating the solution after making the preliminary digestion, and it is best to use the same indicator in both cases.

The other reagents are the same as under "Total acid soluble phosphoric acid."

AVAILABLE POTASH.

Treat 100 grams of soil with exactly 1 liter of N/5 calcium-chlorid solution, exactly as under "Available phosphoric acid." Transfer 500 cc of the filtrate to a porcelain dish, add 4 or 5 cc of concentrated HCl and 1 cc of concentrated HNO_3, evaporate to dryness, take up with a small amount of water, filter, heat filtrate to boiling; add ammonia to alkaline reaction and precipitate lime, etc., with an excess of ammonium carbonate and ammonium oxalate, filter through a 12½-cm paper until clear, wash with hot water, test filtrate with a drop of ammonium carbonate to be sure that the precipitation is complete; add .5 cc of concentrated sulphuric acid, evaporate to dryness in a large platinum dish, heat in the air bath at 150° for one hour, or until danger of popping upon ignition is past, ignite off the ammonium salts, finishing the ignition for a minute over the blast lamp, dissolve the sulphate of potash in water with the addition of 10 drops of concentrated HCl free from ammonium salts by digesting over the water bath for fifteen minutes, filter into a platinum or porcelain dish, wash with hot water, add 2 cc of platinum solution and evaporate to dryness over the water bath; add 1 cc of water and 20 cc of 95 per cent alcohol, place dish over the water bath until the alcohol begins to boil, filter, wash with alcohol, then with ammonium chlorid solution, and finally with alcohol. Good results can not be secured unless the washings are very thorough. Transfer paper and precipitate to an air bath at 110°, dry for thirty minutes, place paper in the funnel, dissolve the precipitate in water almost at the boiling temperature, receive the filtrate in a weighed platinum dish, evaporate to dryness over the water bath, dry at 110° for thirty minutes, cool in a desiccator and weigh.

Reagents.—The calcium-chlorid solution is prepared by dissolving about 12.5 grams of fused c. p. $CaCl_2$ in each liter of water used, filtering, if necessary, and bringing to exact N/5 strength by titrating against standard $AgNO_3$ solution, using potassium chromate as an indicator.

The ammonium carbonate is prepared by dissolving 250 grams of the salt in each liter of water used and adding 100 cc of strong ammonia.

The other reagents are the same as used in the official fertilizer work.

METHODS FOR THE ANALYSIS OF SOILS.

For additional methods of soil analysis, see Methods of Analysis Adopted by the A. O. A. C., September, 1895, pages 38 to 43.

11.—*Total acid-soluble phosphoric acid—Goss method.*

In the case of ordinary soils, transfer 10 grams of the sifted air-dried sample, to a pear-shaped, straight-necked, hard-glass digesting flask which has been marked to hold 250 cc, and add approximately 0.7 gram of yellow oxid of mercury and 20 to 30 cc of concentrated sulphuric acid, as in the determination of nitrogen. Twenty cubic centimeters of acid are usually sufficient, but in the case of very finely divided clay soils, containing little or no sand, it is necessary to use 30 cc to prevent caking of contents of flask. In doubtful cases 20 cc of acid should first be added, and at the end of five or ten minutes, if contents show a tendency to cake, 10 cc more should be introduced. Thoroughly mix contents of flask by shaking, boil for one hour, cool (cold water can not safely be used), add about 100 cc of water, 5 cc of concentrated HCl, and 2 cc of concentrated HNO_3, heat to boiling to oxidize iron, cool (cold water can safely be used), make up to volume and filter through a dry, folded paper until perfectly clear. (In order to secure a clear filtrate it will usually be found necessary to pour the first portion of the filtrate back through the paper three or four times.) Transfer 100 cc of the filtrate to a flask of about 500 cc capacity, add strong ammonia until a permanent precipitate forms, then 6 or 8 cc of nitric acid to dissolve the precipitate, and boil until clear. Cool the solution to 80°, add 75 cc of recently prepared molybdate solution, place the unstoppered flask for fifteen minutes in an open water bath kept at 80° C., shake flask vigorously four or five times while in the bath, then remove and let stand ten minutes to allow the precipitate to settle. Filter through a 9 cm No. 589 S. & S. paper, avoiding too strong a pressure at first, wash the flask and precipitate thoroughly with 10 per cent ammonium-nitrate solution acidified with nitric acid, place the flask in which the precipitation was made under the funnel, shut off pump and close all valves to filtering jar, fill paper half full of hot water, add a few cubic centimeters of strong ammonia, and aid solution if necessary by stirring the precipitate with a glass rod. As soon as the yellow precipitate has all dissolved open valve to the filtering jar, but do not turn on the pump at first as there is danger of loss from spattering. After the solution has passed through, rinse paper once with a small amount of hot water, remove the flask, and place a small lipped beaker under the funnel, heat the solution in flask to boiling, and again pour through the paper, avoiding the use of the pump at first. It is well to have the beaker covered with a perforated watch glass, through which the funnel passes, to prevent loss from spattering. The flask and paper are to be washed out with a small amount of hot water (the total filtrate should not exceed 50 cc).

As has been pointed out by Hilgard, aluminum is sometimes carried down with the phosphoric acid from soil solutions when precipitating with molybdate solution, in which case some of the phosphoric acid will not be dissolved in the treatment with ammonia. This will be indicated, first, by the appearance of a white precipitate upon dissolving the yellow precipitate in ammonia; and second, by the difficulty experienced in washing. If such a precipitate be present in any appreciable quantity, proceed as follows: After washing out all the ammoniacal solution as directed above, place a small beaker under the funnel, close all valves, fill the filter one-third full of hot water, add a few cubic centimeters of concentrated HNO_3, proceed as if dissolving phosphomolybdate in ammonia, receiving final solution and washings in the flask previously used, dilute with water to about 100 cc, add 20 cc of 75 per cent ammonium-nitrate solution, precipitate with 50 cc of molybdate solution in exactly the same manner as before, filter off the precipitate, wash, dissolve in ammonia, and add to first portion.

To the warm ammoniacal solution in the beaker, add HCl until the yellow color appears, then add a few drops of ammonia until the solution clears, cool, add 5 cc of filtered magnesia mixture from a burette, a drop at a time, with constant stirring, let stand fifteen minutes, add 20 cc of strong ammonia sp. gr. 0.90, allow to stand over night, filter, wash precipitate with dilute ammonia, dry, ignite intensely over blast lamp until white or nearly so, cool in a desiccator and weigh the $Mg_2P_2O_7$ secured.

The reagents used which have not already been described are the same as used in the official fertilizer work.

For a detailed discussion of this method see A. O. A. C. Report for 1894, page 58.

12.—*Total nitrogen.*

Weigh out from 7 to 14 grams of soil, transfer to an ordinary small-sized Kjeldahl digesting flask, and boil for one hour with 30 cc, or as much as may be required, of concentrated sulphuric acid and 0.7 gram of yellow oxid of mercury. Remove from over flame, and while still hot carefully add crystals of potassium permanganate until the green color is permanent after stirring, cool, fill flask about half full of water, shake contents, and after allowing the heavy portion to subside, pour the solution into a flask of 1,000 or 1,200 cc capacity, continue the washing by decantation until all the ammonium sulphate has been removed, and continue the determination exactly as under the Kjeldahl method for fertilizers, as given in the Methods of Analysis adopted by the A. O. A. C., September, 1895, pages 16 and 17.

While unnecessary in all ordinary cases, if the soil be known to contain an unusually large amount of nitrates the Kjeldahl method, as modified to include nitrates, should be used.

It is necessary to use an unusually large-sized distillation flask in order to prevent violent bumping and consequent breaking of flasks on account of the bulky precipitate present.

AMENDED AND ADOPTED REPORT OF THE COMMITTEE ON RECOMMENDATIONS IN RELATION TO SOILS.

It is recommended—

(1) That the further trial of fifth normal HCl for determining the phosphoric acid requirements of soils be referred to the reporter for 1897.

(2) That the trial of ammonium chlorid, calcium chlorid, etc., for determining the potash requirements of soils be referred to the reporter for 1897.

(3) That on page 42, section 8, under "Determination of total nitrogen," the description of the method as given by the reporter be substituted for that as printed in the proceedings for 1895.

(4) That the reporter for 1897 test the applicability of the determination of the nitrogen in the humus as a means of ascertaining the need of nitrogen fertilization (proposed by Hilgard), and that the humus for this purpose be obtained by the Husten method.

(5) That the question of the necessity for more general acid tests of soils be referred to the reporter for 1897.

H. J. WHEELER,
For Committee on Recommendations of Reporters.

The PRESIDENT. I notice that the Assistant Secretary of Agriculture is present, and I am sure we will all be glad to hear from him. He was actively connected with the association at its beginning.

Mr. DABNEY. I do not feel that I am a stranger here, although I have been away so long that I feel somewhat like a prodigal son returning to his father. I have watched with much interest the work of this association, and I regard it as the best technical association in this country, if not in the world. It has been to me a matter of pride to see the great and helpful work which it has done. I regret that circumstances over which I had no control have kept me away from the meetings of this association for so many years. I recall with pleasure the memories of my earlier associations with this body, and I would advise young men to stick to their desks, and not wander off into executive work. Molecules and atoms are far more attractive, as a rule, than men and affairs.

I thank you, gentleman, for the invitation which was extended to me to be present, and for this opportunity to say a word to you.

The PRESIDENT. The next thing in order is the presentation of papers on soil and soil analyses.

Mr. Huston read a paper on the subject.

SOIL SOLVENTS FOR AVAILABLE POTASH AND PHOSPHORIC ACID.

By H. A. HUSTON and J. M. BARTLETT.

It seems to be accepted that in the case of worn soils solution in strong mineral acid gives little insight into the availability of their potash and phosphoric acid. More recently the use of dilute organic acids, such as the 1 per cent citric acid used by Dr. Bernard Dyer[1] and the acid ammonium oxalate used by Dr. A. M. Peter,[2] has been tried with more promising results. The theory of the use of dilute organic acid solutions seems to rest on the idea that plant roots give off fluids containing organic acids which act on the soil in a degree comparable with the effect of the dilute acids employed in the laboratory experiments.

While I do not question that plant roots in contact with polished marble or even granite may make appreciable markings on the carbonate of lime and on the feldspar of the granite, the conditions of the experiment as usually conducted differ radically from those found in the field, for in the experiment the plants are not supplied with normal soil water. So far as I have observed, normal soil waters give an alkaline reaction. No inconsiderable part of the food of the plants comes to it dissolved in the soil waters. The work of Dr. J. H. Wheeler[1] shows what marked difficulty is encountered in growing plants on a well-drained soil having an acid reaction.

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[1] Jour. Chem. Soc. London, March, 1894. This paper contains a résumé of suggestions by various authors and special investigations by Dr. Dyer.

[2] Chem. Div. U. S. Dept. Agr., Bull. 47, p. 32.

Soil waters rising from a subsoil are charged with more or less of mineral salts; and if the upper layers of the soil have a different composition from the lower layers in which the soil waters have been charged we may expect chemical changes to take place according to the well established facts of soil absorption.

In view of these considerations some work was undertaken with alkaline solvents. The first solution used contained the same amount of ammonium oxalate as the solution used by Dr. Peter; but instead of the acid an amount of ammonia equivalent to the acid was added. All work is based on the same relative quantities of soil and solution as used by Dr. Peter—200 grams soil and 1,000 cc solution. In working with Dyer's solution the digestions continued at room temperature for seven days with shaking at frequent intervals. All the other digestions were continued for five hours with constant shaking in the apparatus described in Indiana Agricultural Experiment Station Bulletin 55, and Wiley's Principles and Practice of Agricultural Analysis, Volume II, page 142. The flasks were inverted every thirty seconds. The utmost care was used to secure clean precipitates of potassium platinic chlorid.

THE SOILS USED.

The Kentucky soils are those used for work by the Association of Official Agricultural Chemists for the past two years, and are described on page 31 of Bulletin 47, Chemical Division United States Department of Agriculture. Briefly stated, the soil requires the addition of potash to produce satisfactory crops of corn, potatoes, and tobacco, but seems to contain enough available potash for a good wheat crop. The field tests indicate abundance of available phosphoric acid. Soil No. 1 has received phosphoric acid and nitrogen, and soil No. 2 has received potash and nitrogen. Of the Indiana soils the one marked "Turley" is from Orange County. It is a medium clay, resting on a red clay, which in turn rests on the limestone rock of the region.

The land has been under cultivation for some seventy years and at one time was so badly worn as to be considered of very little value. The sample was drawn after plowing for corn in the spring of 1896. In 1895 wheat had been so poor on this land that hogs were turned in to eat the standing crop. In the spring of 1896 the clover was so uneven that the land was put in corn, of which it produced in this very favorable year for corn 37 bushels per acre on the unfertilized plats. The owner does not believe that it can produce a profitable crop of wheat without the use of some commercial fertilizer or manure. The usual application has been 100 pounds ground bone per acre. The field tests this year showed marked gain in corn from the use of acid phosphate and potash, but increasing the amount of potash from 30 to 60 pounds per acre gave no increased yield. Original timber, oak.

The soil marked "Campbell" is from Monroe County, and represents a cold, badly drained clay, resembling the so-called "crawfish" clay. Commercial fertilizers are considered necessary for wheat. Field tests this year showed marked gains on corn from the use of acid phosphate and potash, but increasing the amount of potash from 30 to 60 pounds per acre gave no increased yield. Original timber, poplar and mixed hard woods.

The station land is a second-bottom soil resting on gravel. It is a dark, productive loam. In favorable seasons the land will produce 50 bushels of corn and 30 bushels of wheat per acre without the use of fertilizers or manure. While commercial fertilizers have some effect in increasing the crops, the use of them on this land has not been profitable. Original timber: Black walnut, oak, maple, wild cherry, and some hickory. The plats from which the samples were drawn have been in wheat since 1888. Plats 3 E. 1 and 3 E. 4 have received no fertilizers, plat 3 E. 2 has received "complete" chemical fertilization, and plat 3 E. 5 has secured applications of barnyard manure. In five years (1890 to 1894) 3 E. 1 lost to crop 8.1 pounds phosphoric acid, 11.3 pounds potash, and 17.8 pounds nitrogen; plat 3 E. 4 lost 7.2 pounds phosphoric acid, 10.1 pounds potash, and 15.9 pounds nitrogen; plat 3 E. 2 lost net 0.8 pound phosphoric acid, 3.2 pounds potash, and 7.9 pounds nitrogen; plat 3 E. 5 gained 4.2 pounds phosphoric acid, 6.9 pounds potash, and 0.3 pound nitrogen. The plats contain one-tenth acre each. Plat 3 E. 4, a blank plat, contains humus (by Huston's method)[1] 5.3 per cent, and nitrogen in this humus 4.52 per cent. Plat 3 E. 5, which has received barnyard manure, contains humus 5.6 per cent, and nitrogen in this humus 5.71 per cent.

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[1] Rhode Island Agr. Exp. Sta., 7th Ann. Rpt., p. 152.

The mechanical analyses of the Indiana soils are shown in Table I.

TABLE I.

Source.	Gravel.	Coarse sand.	Sand.	Silt.	Clay.	Moisture and organic.	Total.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Turley	0.25	0.16	7.05	39.82	47.64	5.31	100.23
Campbell	1.57	.67	12.23	45.02	35.21	5.08	99.78
Station 3 E. 4	1.56	2.56	13.95	35.42	36.54	9.94	99.97

Since Peter's solution and the alkaline ammonium oxalate contain a salt of ammonia it was thought that the phenomena of soil absorption might come into play. To test this a solution of the same alkalinity but containing the same amount of ammonia as chlorid as was contained in the other solutions in the form of oxalate was used. To test the question of soil absorption pure and simple a neutral solution of ammonium chlorid, 17.2 grams to the liter, the same amount of ammonium chlorid as in the previous solution, was used.

The soils were also digested with ammonium hydrate, sp. gr. 0.96, containing 17.2 grams ammonium chlorid per liter, and with ammonium hydrate, sp. gr. 0.96, alone. Ammonium hydrate was tried because, as I have previously shown,[2] phosphates of iron and alumina are dissolved by ammonium hydrate. At first we hoped to utilize the ammonia and ammonium chlorid mixture, but in the presence of the ammonium chlorid not a trace of phosphoric acid was dissolved.

On the Kentucky soils a number of solvents were tried at a higher temperature. This modification seemed no improvement, rather the reverse, and it was decided to use room temperatures.

Table II contains the results of the work. The total potash in each soil, and the amount of potash and phosphoric acid removed by hydrochloric acid, sp. gr. 1.115, are also added for purpose of comparison.

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[1] Chem. Div. U. S. Dept. Agr., Bull. 38, p. 84; Wiley's Agr. Analysis, vol. 1, p. 326.

[2] Chem. Div. U. S. Dept. Agr., Bull. 31, p. 99.

TABLE II.

Source of sample.		Dyer's solution 100 per cent citric acid (room temp.; 7 days).	Peter's solution (room temp.; 5 hours).	Alkaline am. oxalate (room temp.; 5 hours).	Alkaline am. chlorid (room temp.; 5 hours).	Peter's solution (65° C.; 5 hours).	Alkaline am. oxalate (65° C.; 5 hours).	Alkaline am. chlorid (65° C.; 5 hours).	Ammonia, sp. gr. 0.96 (room temp.; 5 hours).	17.2 grams am. chlorid in 1 liter ammonia, sp. gr. 0.96 (room temp.; 5 hours).	17.2 grams am. chlorid in 1 liter water (room temp.; 5 hours).	Total potash by J. L. Smith method.	Soluble in HCl, sp. gr. 1.115, on steam bath.
Kentucky:		*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	
No. 3, potash and nitrogen.......	P_2O_5..	(.0541)	.0628	.0138	0	.0492	.0222	0	.0337	0	0	....	.431
	K_2O..	(.0069)	.0189	.0226	.0176	.0185	.0173	.0196	.0140	.0162	.0238	1.485	.340
No. 1, phos. acid and nitrogen...	P_2O_5..	(.0560)	.0776	.0165	0	.0565	.0195	0	.0352	0	0	.....	.432
	K_2O..	(.0038)	.0183	.0144	.0134	.0200	.0135	.0165	.0148	.0137	.0218	1.467	.317
No. 1-No. 3.......	P_2O_5..	(.0019)	.0148	.0027	0	.0073	—.0027	0	.0015	0	0	.....	.001
No. 3-No. 1........	K_2O..	(.0031)	.0015	.0082	.0042	—.0015	.0038	.0031	—.0008	.0025	.0020	.0018	.023
Indiana:													
Turley..........	P_2O_5..	.0028	.0031	.0025	0	......	......	.....	.0025	0	0	.....	.056
	K_2O..	.0321	.0370	.0262	.0248	......	......	.....	.0083	.0274	.0398	2.147	.354
Campbell........	P_2O_5..	.0073	.0303	.0016	0	......	......	.....	.0035	0	0	.....	.045
	K_2O.	.0244	.0232	.0161	.0188	......	......	.....	.0058	.0152	.0257	1.898	.283
Experiment stations:													
3 E. 1, blank flat..	$P_{25}O$.	.0047	.0553	.0157	0	......	......	.....	.0304	0	0	.....	.124
	K_2O..	.0267	.0244	.0150	.0176	......	......	.....	.0073	.0177	.0331	1.958	.450
3 E. 2, chemical fertilizers......	P_2O_5..	.0053	.0530	.0156	0	......	......	.....	.0298	0	0	.....	.118
	K_2O..	.0258	.0254	.0180	.0259	......	......	.....	.0067	.0183	.0309	1.876	.470
3 E. 4, blank flat..	P_2O_5..	.0025	.0447	.0140	0	......	......	.....	.0227	0	0	.....	.121
	K_2O..	.0246	.0275	.0155	.0136	......	......	.....	.0082	.0186	.0319	1.955	.447
3 E. 5, manure....	P_2O_5..	.0019	.0479	.0157	0	......	......	.....	.0231	0	0	.....	.107
	K_2O..	.0268	.0314	.0158	.0300	......	......	.....	.0104	.0218	.0334	2.035	.471

It will be seen that Dyer's solution and Peter's solution resemble each other in a general way in their action on the phosphates of the Kentucky soil (rich in phosphates) and on the Turley soil (poor in phosphates); while on the Campbell land (poor in phosphates) and on the station land (fairly good in phosphates) they differ radically.

In their action on potash the two solutions differ widely in the case of the Kentucky soils containing too little available potash for corn, while they resemble each other in their action on the other soils which seem from field tests with corn to contain considerably higher available potash than the Kentucky soils.

Dyer's solution extracts more phosphoric acid from the Kentucky soil that had received phosphoric acid than from the one receiving none. From the station soil it extracts the highest phosphoric acid from the soil that had received superphosphate; but it failed to extract as much phosphoric acid from the soil receiving its phosphoric acid in the form of manure as it extracted from either of the plats that had received no fertilizers. On the average, Dyer's solution extracts no more phosphoric acid from the station soils known to contain a fair supply of available phosphoric acid than from the clay soils known to be very deficient in phosphoric acid.

Dyer's solution dissolves more potash from the Kentucky soil that had received potash than from the one not receiving any.

From the clay soils, which seem from field tests with corn to be somewhat deficient in available potash, it dissolves relatively high amounts of potash. From the station soils it dissolved no more potash from the soil that had received full applications of muriate of potash than from the soils that had received no potash.

Peter's solution would indicate that there was a good supply of available phosphoric acid in the Campbell soil, where it is known to be deficient. It would also indicate that the Turley land was higher in available potash than the station soil, although the field tests indicate to the contrary.

The acid solutions of Dyer and Peter seem to fail when applied to soils of different types, although their indications are in the right direction when applied to soils of exactly the same type, such as the Kentucky soils.

The alkaline ammonium oxalate dissolves practically as much potash from the Kentucky soil as from the station soil, although the available potash is much higher in the latter, as shown by field tests.

It dissolves about the same amount of phosphoric acid from the Kentucky soil as from the station soil, both of which have a fair amount of available phosphoric acid, although the former has a much higher total phosphoric acid content. It distinguishes these soils very sharply from the clay soils known to be deficient in phosphoric acid.

The alkaline ammonium chlorid distinguishes the fertilized from the unfertilized plats very sharply on the station soil and to a fair extent on the Kentucky soil. Its action on the clay lands is in accord with what knowledge we have in regard to the potash in these soils.

The ammonium chlorid dissolved in ammonia, sp. gr. 0.96, gives results on potash in the same general direction as the mildly alkaline ammonium chlorid, but the differences are less sharply defined. As this solution is rather troublesome to work with, I would prefer to use the mildly alkaline one.

The neutral ammonium chlorid distinguishes very well the Kentucky soil from the station soil, gives fair indications on the clay soils, but fails to show the effect of the potash salts applied to the station soil.

Ammonium hydrate, sp. gr. 0.96, gives results on potash that are quite at variance with what is known about these soils, but on phosphoric acid it gives promising results. The character of the individual results indicates that the digestion was not continued long enough to complete the reaction. Yet the results clearly distingished the lands poor in phosphoric acid from those known to be well supplied with available phosphoric acid. The only case where it seems at fault is on plat 1 of the station soil. But every other solvent acts in the same way, indicating that the sample from this plat is really higher in phosphoric acid than the sample from the other blank plat, No. 4. Crop tests covering five years show that plat 1 has a crop-producing capacity about 15 per cent greater than plat 4.

Ammonium chlorid in neutral and alkaline solution removes notable quantities of lime from soils. The quantities were determined and are given in Table III.

TABLE III.

Per cent of calcium oxid removed by various solvents.

Source of sample.	By alkaline ammonium chlorid (5 hours; room temp.).	By neutral ammonium chlorid (5 hours; room temp.).	By HCl., sp. gr. 1.115 (10 hours on steam bath).
Kentucky No. 3	0.144	0.173	[1] 0.51
Kentucky No. 1	.122	.196	[1] .31
Turley	.066	.122	....
Campbell	.114	.143	....
Station 3 E. 1	.096	.216	....
Station 3 E. 2	.089	.246	....
Station 3 E. 4	.113	.226	.447
Station 3 E. 5	.105	.227	.472

[1] Determined by Harry Snyder. See Bull. 47, U. S. Dept. Agr., Chem. Div., p. 49.

It will be seen that the alkaline ammonium chlorid removes about one-fourth and neutral ammonium chlorid about one-half as much lime as the hydrochloric acid used in the customary method of soil analysis. The station soils are practically free from carbonates, containing an average of only 0.015 per cent of carbon dioxid.

Of the solvents used we consider alkaline ammonium chlorid and neutral ammonium chlorid promising for available potash and ammonium hydrate promising for available phosphoric acid. Alkaline ammonium oxalate seems to do very well for available phosphoric acid in some cases, but the material is rather troublesome to work with on account of the large amount of organic matter that goes into solution. Where ammonium chlorid is present the solutions are nearly free from organic matter, filter very rapidly, and the ignition is readily made, leaving only a small amount of bases to be removed before determining the potash. Tatlock's method was tried for potash, but proved unsatisfactory.

We have tried chlorids of calcium, magnesium, and sodium, but prefer to use the ammonium salt, since it introduces no involatile base which would interfere with the potash determination.

We are now at work with ammonium hydrate, continuing the digestion for a longer time and changing the strength of the solution. We are also testing ammonium chlorid dissolved in 1 per cent hydrochloric acid. We shall also test the question of the relative quantities of the soil and solvent used, as the present amounts—200 grams soil to 1 liter of solvent—seems to involve too small a volume of solvent. While we feel encouraged by the outcome of the work reported above, it must be borne in mind that before any method of soil testing can be considered satisfactory, it must give reliable indications on soils of different types that have been subjected to investigation by field tests; and these tests must not be confined to one crop, but must relate to all the crops likely to be produced on the land under investigation. From data now at hand it seems probable that certain soils may have ample potash in an available form to produce good crops of cereals, while not having enough to produce profitable crops of corn, potatoes, or tobacco. This phase of the matter must be kept in mind in deciding upon any definite amount of soluble ingredients which shall be used as a minimum in judging of the fertilizer needs of a soil.

PURDUE UNIVERSITY AGRICULTURAL EXPERIMENT STATION, *November, 1896.*

The **PRESIDENT**. The discussion of Professor Huston's paper is in order, but the time set by the order of business for the election of officers has arrived.

We will now hear from the committee on nominations.

The committee presented the following names: For president, William Frear; for vice-president, A. L. Winton; for secretary, H. W. Wiley; for member of the executive committee, B. W. Kilgore.

The report of the committee was unanimously adopted, and the gentlemen above mentioned declared elected to the offices for which they were nominated.

The **PRESIDENT**. I would like to ask Mr. Wiley if it is not true that we practically have no man to become reporter on soils next year?

Mr. **HUSTON**. The chairman appoints the reporters.

Mr. **WILEY**. It would be best for this society to have the reporters serve two years instead of one, and it would not be a very great additional burden upon the reporter.

Mr. **KILGORE**. As I understand this matter, when it was brought up two years ago it was the intention that reporters should serve two years, and it must have been the impression of the incoming president at that time that such was the case, because he immediately reappointed all the old reporters, and there are quite a number of them who have served two years; and I am quite sure we have a good set of reporters, and that the duty is so pleasant that, even if they do not have the time, they would be willing to work at nights to do this work.

Mr. **Wiley**. The constitution itself says nothing about the matter. It was really left to the discretion of the president with the recommendation that the resolution adopted at that time be carried out.

Mr. **Kilgore**. I think the understanding was very clear that the associate reporter was to work with the reporter and the associate was to be worked into the place, but I do not know of any case where this has been done.

So far as the real work is concerned the reporter has done it all in most every case, and I think this plan has been a pretty successful failure.

Mr. **Wheeler**. I think the great difficulty has been that the reporter and associate reporter have been so very far separated.

Mr. **Lindsey**. Dr. Wheeler served two years and did his duty. It was my intention, when I made that motion, that the reporter should serve two years. There was a sort of entanglement. It is for the benefit of this association, as a rule, that a reporter should serve two years, and I think he ought to have the interest of the association sufficiently at heart to do it. Of course it takes a considerable portion of his time, but nevertheless it is in a good cause. A man begins as a reporter; of course he looks up the subject thoroughly and he gets started out on his work and makes out a line and accomplishes something the first year, but he learns in the first year that he has made mistakes and knows how to go to work to remedy them the next year. If you take the second year away, all the work of the first year is lost and it is transferred to another member, and he makes some mistakes and does not accomplish nearly as much for the benefit of the association as he wonld if he continued two years in office. With that in mind, I would very strongly favor that the reporters, for the benefit of the association, serve two years in succession.

The **President**. Do you make a motion that a provision of that kind be inserted in the constitution?

Mr. **Lindsey**. How would it be to have the motion read, that "it be the sense of the association that reporters serve two years," and leave it to the judgment of the president to appoint a reporter for that period?

Mr. **Huston**. I would like to make an amendment to that motion that instead of two successive years, he be allowed to serve more than one year. I do not think we had better put a limit on him.

The **President**. Do you move that as an amendment?

Mr. **Bigelow**. I would like to have the constitution read.

Constitution read.

The **President**. As many as favor the adoption of the amendment say "aye."

Amendment adopted.

The **President**. The question now is upon the adoption of the motion as amended.

Motion adopted.

The **President**. Any further paper on the subject of soils and ash analyses? If there are no further papers, the discussion of the report is in order.

Mr. **Kilgore**. I would suggest that it is proper to present suitable resolutions with reference to the death of a man who has been a very strong friend of this association and who has done a great deal for it—ex-Assistant Secretary of Agriculture Willits. As we all remember, the remarks before this association in the year past were very hopeful and encouraging, and I feel it is the duty of this association to appoint a committee to prepare a suitable set of resolutions. I move that a committee be appointed to draft them.

Motion carried; and the president appointed Mr. Kilgore, Mr. Huston, and Mr. Wiley on the committee.

The **President**. If there is nothing further on the subject of soils and ash, the report on dairy products is in order.

On two of the other subjects we have no formal reports, which will bring down the amount of business to a very narrow margin if we attempt to do anything more to-day. For that reason I think a motion to adjourn would be acceptable.

Reporter on Dairy Products. I should like to get rid of my report to-day. It will not take a very long time, and I shall not take more than ten minutes to dispose of it.

The **President**. What is the pleasure of the association in regard to this matter?

Moved and adopted that the reporter be allowed to read his report.

Mr. Van Slyke then read his report, as follows:

REPORT ON METHODS FOR THE ANALYSIS OF DAIRY PRODUCTS.

By L. L. Van Slyke.

It was the purpose of the reporter to give special attention to the analysis of cheese, in order that the provisional methods might be adopted as permanent in so far as additional work seemed necessary to accomplish this result. Methods for some determinations have been so carefully worked out that they do not require any further attention.

Two points in particular have received attention: (1) Preparation of sample, and (2) determination of fat. In addition the acidity of cheese has received some study. The first of these has been found to be a matter of no small difficulty. Until this year different workers used different samples, but this year it was desired to have work done on one and the same sample.

PREPARATION OF SAMPLE.

A wedge-shaped segment was cut from the cheese, reaching from the outer edge to the center of the cheese. This was cut into strips and passed through a sausage-grinding machine three times, being mixed as completely as possible after each grinding. Small jars were filled from the cheese thus prepared and these samples sent out for analysis.

In order to ascertain how completely and uniformly mixed the samples were, determinations were made of the nitrogen in samples contained in five different jars, selected at random. The results were as follows:

Nitrogen in—				
No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
Per cent. 4.71	*Per cent.* 4.79	*Per cent.* 4.73	*Per cent.* 4.72	*Per cent.* 4.78
4.72	4.82	4.76	4.75	4.87

These results show that the samples of cheese sent out were as nearly uniform as it would be possible to make them, but it is possible that the fat was less uniformly distributed than the nitrogen compounds.

DETERMINATION OF FAT.

It was proposed to compare the following methods for the determination of fat:

1. The present provisional method.
2. The present provisional method modified.
3. Extraction of fat after drying.
4. Babcock test.

The present provisional method is, briefly, as follows: The sample of cheese is ground with about twice its weight of anhydrous copper sulphate and then extracted with ether.

The proposed modification avoids grinding the weighed sample until the fat has been mostly extracted, thus preventing possible loss of fat. In detail it is as follows: Use a test tube containing a perforation in the bottom, or, in place of this, an extraction thimble of fat-free paper. When a test tube is used, place at the bottom some extracted cotton, glass wool, or asbestus, and in addition wrap the lower end outside with filter paper to prevent particles of asbestus or copper sulphate being carried down through the perforation into the extraction flask. Pack the prepared tube as follows: Put first a mixture containing equal parts of anhydrous sulphate and pure incinerated sand, filling the tube for about 2 inches. Avoid packing too tightly. Upon this place a little asbestus or other suitable material. Then place the sample of cheese, which has been weighed out for analysis. It is very convenient to place the weighed sample in a little cone of copper foil or of filter paper and slip this into the top of the tube containing the copper sulphate.

The extraction is carried on as usual. After five hours the partially extracted cheese is removed and ground with pure sand in a mortar. This partially extracted cheese is brittle, and grinds up about as easily as a dry cracker. After grinding with the sand the cheese is replaced in the tube and the extraction continued ten hours longer. In the grinding there is no danger of loss of fat, because the cheese is largely extracted in five hours, and little fat remains in the residue that is ground.

The extraction after drying is accomplished as follows: Weigh out 2 to 5 grams of cheese, dry at a temperature of boiling water for ten hours, and then extract with ether. After five hours remove the cheese and grind with some incinerated sand. Replace in flask and continue extraction for ten hours longer.

The Babcock test is made in the following manner: Use cream tubes; those designed by Mr. Bartlett, of the Maine Experiment Station, are satisfactory. Test the calibration of all bottles used. Weigh the test bottle, and place in it about 8 grams of cheese, then add about 15 cc of hot water and place upon a water bath until the cheese becomes soft, so that by shaking the bottle a uniform mixture is obtained. Complete the test in the same manner as with milk. Multiply the final reading by 18 and divide the product by the weight of cheese taken, in grams, to obtain the per cent of fat. If a sample of cheese do not dissolve readily in this way, add a few drops of strong ammonia in the bottle after the water is added, and this will soon soften the cheese so that the test can be made. Special attention is called to the precaution that the sulphuric acid should be added slowly in small portions, shaking after each addition, using a little more than is necessary for complete solution.

It is suggested that the extracted residue of cheese in each case be transferred to an ordinary Babcock testing bottle and the amount of fat in such residue determined.

While several assurances in regard to doing the work were received and samples were sent to twelve chemists, only three reported and the results in one case were much too low, owing probably to incomplete extraction.

I will present the results of work done by the following persons: S. M. Babcock, Madison, Wis.; E. N. Eaton, chemist of the Minnesota dairy and food commission, and C. G. Jenter, an assistant chemist in the New York (Geneva) Station laboratory.

Per cent of fat in cheese obtained by the provisional method.

S. M. Babcock.	E. N. Eaton.	C. G. Jenter.
(1) 38.00	(1) 38.48	(1) 38.07
(2) 38.19	(2) 38.68	(2) 38.31
	(3) 38.87	(3) 38.37
		(4) 38.41
		(5) 38.61
Average... 38.10	38.68	38.35
Lowest result		38.00
Highest result		38.87
Extreme difference		.87

Extreme difference expressed in per cent of total average amount of fat found equals 2.25 per cent.

Per cent of fat in cheese obtained by the modified provisional method.

S. M. Babcock.	E. N. Eaton.	C. G. Jenter.
(1) 39.33	(1) 39.60	(1) 38.72
(2) 38.85	(2) 39.73	(2) 38.85
	(3) 39.85	(3) 39.00
		(4) 39.06
		(5) 39.29
Average... 39.09	39.73	38.98
Lowest result		38.72
Highest result		39.85
Extreme difference		1.13

Extreme difference expressed in per cent of total average amount of fat found equals 2.88 per cent.

Per cent of fat in cheese obtained by extraction after drying cheese.

S. M. Babcock.	E. N. Eaton.	C. G. Jenter.
(1) 39.37	(1) 40.00	(1) 39.06
(2) 39.57	(2) 40.13	(2) 39.10
	(3) 40.26	(3) 39.75
		(4) 39.94
Average... 39.47	40.13	39.46
Lowest result		39.06
Highest result		40.26
Extreme difference		1.20

Extreme difference expressed in per cent of total average amount of fat found equals 3.02 per cent.

Per cent of fat in cheese obtained by the Babcock test.

S. M. Babcock.	E. N. Eaton.	C. G. Jenter.
(1) 39.29	(1) 39.83	(1) 39.74
(2) 39.29	(2) 39.94	(2) 39.98
	(3) 40.05	(3) 40.29
Average... 39.29	39.94	40.00
Lowest result		39.29
Highest result		40.29
Extreme difference		1.00

Extreme difference expressed in per cent of total average amount of fat found equals 2.40 per cent.

The foregoing results obtained by the different methods are fully as concordant as could be expected in a determination of this character. Attention is now called to the relative amounts of fat obtained by the different methods studied. Averaging all the results, we have the following:

	Per cent.
Provisional method	38.55
Provisional method modified	39.23
Extraction after drying	39.69
Babcock test	39.81

All the work done indicates consistently and conclusively that the present provisional method gives too low results. That this is due to incomplete extraction, we can easily show. Five portions of the same sample of cheese were extracted by the provisional method for fifteen hours. The residue was then powdered and the extraction continued for five hours. Below are the detailed results.

Per cent of fat obtained in 15 hours extraction.	Per cent of fat obtained by powdering and extracting 5 hours more.
(1) 38.07	(1) 0.36
(2) 38.37	(2) 0.27
(3) 38.41	(3) 0.24
(4) 38.31	(4) 0.46
(5) 38.61	(5) 0.18

The amount of fat obtained by powdering and further extracting the residue, varied from 0.18 to 0.46 per cent, and averaged 0.30 per cent. Even then the results were lower than those obtained by any other method. The difference is probably due to some loss of fat in the process of grinding the cheese with copper sulphate at the start. It is difficult to avoid some loss in this operation. Hence, the present provisional method is subject to two sources of loss: First, loss in process of grinding cheese with copper sulphate; second, loss from incomplete extraction.

The provisional method modified gave on an average 0.68 per cent more fat than the provisional method. In this method the cheese is not ground until most of the fat has been extracted. The whole operation can be carried out somewhat more easily.

It will be seen that the amount of fat obtained by extraction after drying is still greater than by the provisional method or its modification. The fat thus obtained is dark brown in color, giving evidence of impurity. The reporter has not found time to ascertain the detailed reasons for this increased yield of extract, and can not therefore recommend this method at present. It is also noticed that the amount of fat obtained by the Babcock test is higher than by any other method, agreeing most closely with the results obtained by extracting the fat after drying. But this fat has not been examined as to its purity. If further work shall show that the extract which is highest in amount consists of equally pure fat, then it will be found desirable to use the method giving such results. On the basis of the data at hand, I can only recommend the substitution for the present provisional method of the modification which has been studied this year. I would suggest that further work be done in studying the purity of the fat obtained by extraction after drying cheese. The method which gives the largest amount of pure fat is the method desired.

DETERMINATION OF ACIDITY OF CHEESE.

An attempt was made to study the amount of total acids in cheese in accordance with the following instructions: Agitate 10 grams of cheese vigorously with nearly 100 cc of water at a temperature of 40° C.; filter; make up filtrate to 100 cc; titrate portions of 25 cc of the filtrate with a standardized solution of sodium hydroxid, preferably a tenth-normal solution. Use two different indicators for comparison—phenolphtalein and cochineal. Report the amount of actual sodium hydroxid used for 1 gram of cheese.

The sample of cheese used was too old to give satisfactory results for this work. The following suggestion was made by S. M. Babcock:

> On account of the difficulty in filtering acqueous extracts of cheese, especially if the cheese is old, I would suggest that the extract be made up to 105 cc before filtering, 5 cc representing approximately the volume of the insoluble solids of the cheese when 10 grams are taken, and that 25 cc of the filtrate, representing 2.5 grams cheese, be titrated. This would save much time and, I believe, be fully as accurate as the method described, for it is impractical to completely wash the residue on the filter when only 100 cc of water are used.

RECOMMENDATIONS FOR CHANGES IN METHODS OF ANALYSIS OF CHEESE.

1a. *Preparation of sample.*

When the cheese can be cut, a narrow wedge-shaped segment reaching from the outer edge to the center of the cheese is taken. This is to be cut into strips and passed through a sausage-grinding machine three times, being mixed as completely as possible after each grinding, taking care to avoid evaporation of water. From the mass thus prepared samples are taken for analysis.

When the cheese can not be cut, samples are taken by a cheese trier. If only one plug can be obtained this should be taken perpendicularly to the surface at a point one-third of the distance from the edge to the center of the cheese. The plug should reach either entirely through or only halfway through the cheese. When possible draw three plugs, one from the center, one from a point near the outer edge, and one from a point halfway between the other two. For inspection purposes the rind may be rejected, but for investigations requiring the absolute amount of fat in the cheese the rind is included in the sample. It is preferable to grind the plugs in a sausage machine, but when this is not done they are cut very fine and carefully mixed.

2b. *Determination of water.*

Change first sentence to read as follows: From 2 to 5 grams of the prepared sample of cheese are placed in a weighed porcelain or platinum dish which contains a small quantity of material, such as freshly ignited asbestus or sand, etc.

3c. *Determination of fat.*

Substitute for present method the modification described above in this report. Use 2 to 5 grams of material.

4. It is recommended that the following be adopted as a provisional method for the determination of total acids in cheese: Weigh 10 grams of cheese, add water at a temperature of 48° C. until the volume equals 105 cc, and agitate vigorously; filter; titrate portions of 25 cc of filtrate corresponding to 2.5 grams of cheese with a standardized solution of NaOH, preferably one-tenth normal. Use phenolphtalein for indicator. Express amount of acid as lactic acid.

5. It is recommended that the methods of cheese analysis as modified be made official except where otherwise provided.

6. It is recommended that the next reporter make a study of the fat of normal and filled cheese, in order to devise a method for identifying the latter.

7. It is recommended that the next reporter also consider the question of milk adulterants in form of preservatives and study methods of identification.

8. It is recommended to adopt the following as a provisional method for the determination of casein in cows' milk:

The determination of casein in milk should be made when the milk is fresh or nearly so. When it is not practicable to make this determination within twenty-four hours add 1 part of mercuric chlorid to 2,000 parts of milk and keep in a cool place. Weigh about 10 grams of milk, dilute in a beaker with about 90 cc of water at 40° to 42° C., and add at once 1.5 cc of a solution containing 10 per cent of acetic acid by weight. Stir with a glass rod and let stand three to five minutes or longer. Then decant on filter, wash two or three times with cold water by decantation, and transfer precipitate completely to filter. Wash once or twice on filter. The filtrate should be clear or very nearly so. If the filtrate is not clear when it first runs through it can generally be made so by two or three repeated filtrations, after which the washing of the precipitate can be completed. The washed precipitate and filter paper are then digested as in the regular Kjeldahl method for the determination of nitrogen, and the determination of nitrogen is completed as usual. To calculate the nitrogen into an equivalent amount of casein, multiply the per cent of nitrogen by 6.25.

In working with milk which has been kept with mercuric chlorid the acetic acid should be added in small portions, a few drops at a time, stirring after each addition, and continuing the addition of acetic acid until the liquid above the precipitate becomes clear or very nearly so.

9. It is recommended that the following be adopted as a provisional method for the determination of albumin in cows' milk.

The filtrate obtained above in separating casein is placed in a water bath and heated to the boiling temperature of water for ten or fifteen minutes. The filtered and washed precipitate is then treated by the Kjeldahl method for determining nitrogen. The amount of nitrogen multiplied by 6.25 gives the amount of albumin.

AMENDED AND ADOPTED REPORT OF THE COMMITTEE ON RECOMMENDATIONS IN RELATION TO DAIRY PRODUCTS.

It is recommended—

(1) That the method of sampling as recommended by the reporter be adopted as a substitute for the present method.

(2) That the amount of material (cheese) to be taken for water determination be changed to that recommended by the reporter.

(3) That the method recommended by the reporter be substituted for the present method under (c) *Ether extract.*

(4) That the method for the determination of total acid in cheese as described by the reporter be adopted as a provisional one.

(5) That the following methods on page 37 be made official, viz, (a), (b), (c), (d), (e), and (f), with the modifications as above given.

(6) That the method for casein in milk described in 1893 by Dr. Van Slyke be adopted as a provisional one.

(7) That the method for albumin in milk as described in 1894 be adopted as a provisional one.

(8) That the reporter for 1897 be authorized to study methods for identifying filled cheese.

(9) That the reporter for 1897 be authorized to study methods for the identification of milk adulterants used in the form of preservatives.

H. J. Wheeler,
For the Committee on Recommendations of Reporters.

A Modification of the Babcock Method and Apparatus for Testing Milk and Cream.

By J. M. Bartlett.

The modifications described in the paper are, briefly stated, as follows:

First. The modification of the method consists, chiefly, in filling the bottles with hot water after the milk or cream and acid are added, before they are put in the centrifugal machine and whirled, thereby completing the separation with one whirling and saving the time required for the second whirling.

Second. The modifications of the apparatus are: The base portion of the milk bottle is graduated, and the base portion of the cream bottle is reduced in size and graduated so no acid measure is required.

While working with the Babcock test some months ago it occurred to the writer that the hot water might be added directly after mixing the acid and milk together, and that separating the fat before adding water was an unnecessary part of the process, if the right conditions could be brought about. Accordingly, to decide the matter, a number of tests were made with all conditions the same, as in the regular method, except that hot water was added before the bottles were whirled. In this way only partial success was attained. A few of the bottles showed clear separations of fat, but many were cloudy, apparently containing curd. Success in few cases gave encouragement for further trials, so the investigation was continued until the following method was hit upon, which the writer has used successfully for the past six months with all kinds of milk and cream:

METHOD.

After the milk is mixed by stirring, or pouring from one vessel to another, the required amount, 17.6 cc, is measured into the test bottle. It is then heated to about 70° F., if not already at that temperature, by setting the bottle in a tank of warm water, 20 cc of sulphuric acid (sp. gr. 1.82 to 1.825) are added, and the bottle shaken by giving it a rotary motion until the milk and acid are thoroughly mixed. The mixture is then allowed to stand not less than five minutes. No harm is done if it stand longer, and, in fact, occasionally some kinds of milk have to be given a little more time. After standing the necessary time the bottle is given another gentle shake to mix in and dissolve any particles of curd that may have risen to the surface. Hot water is then added nearly to the 10 per cent mark, the bottle put in the centrifugal machine, and whirled for five minutes at the rate of 1,000 to 1,200 revolutions per minute. A steam turbine machine is best for this purpose, but a hand or belt power machine can be used if hot water be put in the pan to keep the fat melted. After the whirling is completed the per cent of fat can be read off in the usual manner.

It would appear that the time required for the bottles to stand after the acid is mixed with the milk would offset that gained by omitting the second whirling, which is made in the old method; but the writer has often found it necessary with many kinds of milk, especially that from cows much advanced in the period of lactation, when the milk is very rich, to allow the bottles to stand a while when working the two-whirling method in order to get a clear separation of fat. However, everyone who does much testing should have at least two sets of bottles, so there would be no loss of time by this process. When two sets of bottles are at hand one set can be charged with the milk and acid and stand while the second set is filling, and the second set can stand while the first is whirling. It is much better to make twelve tests at a time than to make any larger number. Twelve are about all one can easily read off before the fat begins to cool and contract in volume.

For the above-described modification of the milk test no change of apparatus need be made, the writer, however, prefers to have the base portion of the bottle graduated as before mentioned, so no acid measure is required and only one pouring of the acid is necessary.

By having the bottle marked at a point at which it holds 37.5 cc, one can, after the milk is measured in with the pipette, run the acid in until it is filled to this point. It was found impracticable to use a bottle with a smaller base capacity, like the cream bottle described further on, because of the larger amount of curd in milk than in cream and the smaller size of the neck of the milk bottle necessitating more space for shaking, breaking up the curd, and dissolving it in the acid.

THE CREAM BOTTLE.

The bottle before mentioned and herein described is similar to the regular milk bottle, also the Connecticut station cream bottle, except that the base portion is made of such size as to avoid using an acid measure. The base is made to hold about 38 cc up to the neck, and after the cream is measured in the required amount of acid is added if the bottle is filled nearly to the neck. The neck portion is large enough to carry 25 per cent of fat, and is graduated to one-half per cent, but can be easily read to one-quarter per cent. Each per cent is numbered. Although one can not read as closely with this as with the bulb-neck bottle, which was designed to test both milk and cream, and described in Bulletin No. 3, Second Series, Maine Experiment Station, one can read with sufficient accuracy for all practical purposes. On account of the neck being larger and shorter the new style bottle is more easily cleaned than the old, is less liable to breakage, and by using the method previously given for milk a test can be made more rapidly. Twenty-five per cent was fixed upon as the capacity of the neck, for the reason that a much higher per cent necessitates an increase in the diameter, which impairs the accuracy in reading; and again, nearly all cream shipped to the creameries is raised by the cold deep-setting process, and will seldom contain more than 20 per cent of fat. If one wish to test separator cream that is very rich, 9 cc or 9 grams can be taken instead of 18, 9 cc of water added and the usual amount of acid. The per cent of fat obtained in that case of course should be multiplied by two to give a correct reading.

The method employed is practically the same as for milk. That good results and clear separations can be obtained by the previously described modifications the writer and others connected with the college have fully demonstrated. It is necessary, however, that the details of the method be strictly observed to attain success.

Below is given in tabular form a few of the many results obtained on milk and cream in comparing the old process with the one-whirling method:

Per cent of fat in milk.

Milk.		Milk.		Milk.		Cream.	
Whirled once.	Whirled twice.	Whirled once.	Whirled twice.	Whirled once.	Whirled twice.	Whirled once.	Whirled twice.
5.3	5.3	5.2	5.3	3.8	3.7	18¼	18¾
5.6	5.6	5.3	5.4	4.1	4.2	18⅛	18¼
6.0	6.0	4.7	4.8	5.2	5.0	18¾	....
4.9	4.9	5.0	4.9	5.1	5.2	18⅛	....
4.9	5.0	5.8	5.8	5.3	5.1	23⅛	23¼
5.2	5.2	5.0	5.0	5.0	5.0	22¾	....
4.6	4.6	4.9	4.9	5.0	5.2	17	17¼
5.0	5.1	4.9	5.0	5.7	5.8	19¼	19

The convention then adjourned till Monday morning.

THIRD DAY.

MONDAY—MORNING SESSION.

The **PRESIDENT**. We will now proceed with the report of the committee on recommendations of reporters.

Mr. **WHEELER**. There is one matter that I ought perhaps to have mentioned in connection with soils. If it be agreeable to the convention I will bring it up now; if not, will let it go until another time.

The **PRESIDENT**. I suppose there is no objection.

Mr. **WHEELER**. The point is this: We have performed experiments at some twelve points in Rhode Island and found that a number of soils are so deficient in bases that the reaction of the soil becomes acid, even on hilltops which have a gravelly subsoil where the drainage is excellent. It seems that the test for acidity may in some cases in upland and well-drained soils be very important as indicating a sufficiency of bases and it might be wise to have a test for the reaction of soil introduced into our soil analyses. It is recognized by many, but there are many others who do not take it into consideration. I presented a paper last year in this line. With us it is a most important matter.

The **PRESIDENT**. Any remarks on this subject?

Mr. **WILEY**. It is unusual for any of us to think of testing well-drained soil, but I think it is a matter of considerable importance and that it should be looked into more carefully hereafter. I think if the reporter were instructed to consider this question it would be a matter of importance. I move, therefore, that the reporter be instructed to consider the question of testing the acidity of soils.

Motion seconded and adopted.

Mr. **WHEELER**. I will now offer the recommendations on phosphoric acid, as agreed upon by the committee.

The recommendation that the volumetric method be adopted as official was the subject of the following discussion:

Mr. **WILEY**. The first problem which presents itself to my mind is one I supposed was settled by the national election—that is, Can we have two standards for the same thing? I believe that our standard method, which is recognized as a standard—that is, the gravimetric method—should remain as the only standard of value for the measuring of phosphoric acid, but I believe analysts should be allowed to use other methods in their routine work as well as in their official work. I would object, however, in the light of our present experience, to adopting it as an equal standard with the official gravimetric method. I believe we would be taking a dangerous step in doing this, because the method is not yet sufficiently developed. It seems to me it would be a great deal better if we would allow it to remain as an optional method, but we ought not to try a double standard.

Mr. **Kilgore**. As to what is a standard, or what should be the standard, I do not think that any method should be taken as a standard, but a theoretical percentage of pure salt should be used, as in the case of the potash work. For the past three years the reporters rather than take any method as a standard have used the theoretical percentage of salt and by that method they have proven our present potash method to be a most excellent one. I take it that this pure phosphate salt should be taken as the standard rather than any one method. We ought to take what actually is as a standard rather than a method.

Mr. **Wiley**. How do we determine the purity of a salt? We would determine the purity of a phosphate salt by the gravimetric method. We can not rely upon any commercially or chemically pure salt which is sent out. We must first test it and be sure that the salt is pure. If the salt be certainly pure, as far as that particular salt is concerned the methods would be directly applicable. If we had the whole volumetric as an optional method or as an alternative method my opposition would at once disappear. But I would object as a member of this association to have it adopt the volumetric as a standard method or place it on an equality with the gravimetric method.

Mr. **Van Slyke**. As a member of the committee on recommendations, my understanding was that it was recommended as an optional method.

Mr. **Myers**. I am disposed to take the position that Mr. Wiley has. I doubt the advisability of the association recognizing in full force a system of analyses which can not be worked uniformly by different chemists in different places, and which is treacherous under any circumstances, so that any chemist who may get the results correct a portion of the time may expect a disappointing result at an unexpected moment.

In regard to this volumetric method, we have tried honestly and very hard to get the chemists at our laboratory to use it so that we could employ it in our operations in fertilizer analyses. There are several reasons why it is desirable to have a quick method on fertilizer analyses if we can get a reliable one, but with four or five chemists I have had at work trying their best to get it into shape to work satisfactorily we have failed utterly to get results that we could depend on as we can upon the gravimetric method, and while the chemists at work have had full liberty to use it if they wished I notice they have uniformly abandoned it, for the reason that if they had used it they were very liable to have to review their work by the gravimetric method in order to determine whether their volumetric method was correct.

We have, it is true, an optional method in potash determinations, and I will venture to say that every chemist here, at least a large number of chemists, will agree with me that perhaps there is no element in fertilizer determinations at present that is in a more satisfactory condition than the potash determinations. We have a standard that is recognized the world over for phosphoric-acid determinations. Shall we stamp as official a method that will bring into that an element of confusion? I doubt very much the advisability of it. I have no objection to chemists, if they can use this method with precision in their laboratories, employing it if they wish to, but I doubt the advisability of adopting it as an alternative method. I think it should be published as a method to be employed at the option of the chemist if he fail in the other method. But I know it is impossible in some well-organized laboratories in this country to get concordant results by that method. I know that it is impossible for chemists of experience and most careful training to get concordant results by that method. There are elements of inaccuracy in it which have not yet been determined, and while my friend claims that a method giving concordant results upon pure salt has some elements of strength in the argument there are elements entering into this that weaken his argument, because he can not tell what he is working with when he has an impure salt in hand.

Mr. **Kilgore**. In about 325 results with the gravimetric method 276 samples of totals averaged by the official 10.70 per cent, by the volumetric 10.72 per cent. Fifteen solubles averaged by the official 2.61 per cent, by the volumetric 2.55 per cent. The results agreed very closely all the way through.

Mr. **McDonnell**. I should like to see the association adopt it as an alternative method.

Mr. **Wheeler**. Would like to hear from Mr. Kilgore in regard to one point. The point has been raised that discordant results have been obtained in one laboratory. I would like to know if in the results reported from other laboratories such discordant results have been obtained or whether it is confined to this one laboratory.

Mr. **Kilgore**. I would merely refer you to the report of last year, where the method was worked in its present form (p. 76). I gave there, instead of averages, all the results. The results are very satisfactory upon all samples sent out. There were no discordant results that came into my hands last year.

Mr. **Johnson**. I wish to warn this association to proceed very cautiously. The volumetric method is extremely promising, but I am reminded of some of my own experiences in years gone—twenty years ago—when I sought to use one of the later methods as a shorter cut in fertilizer analysis, and at my instigation Mr. Wells, now Professor Wells, of Yale University, made an investigation of that method and he obtained a large number of results just as satisfactory as those obtained by the original method. But now and then we struck a snag, and although for one entire fertilizer season every sample was analyzed by both methods, we finally had to give up the new method as inaccurate. We can not afford to make any mistakes; we can not afford to use a method that we do not positively know is the very best.

Mr. **Scovell.** Mr. Johnson has suggested a thing I have been thinking about for some time. If we adopt the volumetric as an alternative method, we adopt it as a legal method, because the courts have decided that official methods are legal methods. I remember a case this spring where a party got 2 per cent more phosphoric acid than we did. On investigation we found they were using the volumetric method, and I proved to them that that was not the official method, because we had not adopted it as an alternative method. If we adopt it as an alternative method these manufacturers could make these analyses by this method. That is, I think, a serious objection to adopting it as an alternative method. As the controller of fertilizers in my State I have to look further than most chemists. I have to sign all of the analyses, and I want to be sure before signing them, and I know by the present methods they are all right. I would hesitate if the analyses were made by the alternative method, because I might get into difficulty. If we can go before our courts and show that we are accurate, that we adopt only the best methods, we have won the battle already; but if we show that we adopt methods that are not accurate, the courts may decide that these are not the best methods. When we adopt a method we want it universal.

Mr. **Wheeler.** I will say that, for my part, I should hesitate very much to make this method a method to be exhibited in court under the present circumstances. I supposed that it was understood that in court cases the standard gravimetric method was the only method allowable.

Mr. **Huston.** I suppose it is understood that the committee in recommending this method act upon the light which is presented to the committee. We had three men at least who have done an enormous amount of work upon this, and they have spoken very favorably of this method. I am frank to state here, as I did before the committee, that I do not wish to prevent anyone who desires to use this method from using it, but I will not allow this method to be used in my own laboratory, because the results which we have obtained are very far from being satisfactory; at the same time, I do not consider I have given the matter a full trial. My assistant absolutely refused to do the work by that method. The class of material, however, which we have is different from the general fertilizer material. I feel, however, that our experience ought not to count against that of those who have used the ordinary material. It was not in our hands applicable to that kind of material. I think there are some present who are neither station men nor official chemists, and I hope these men will appreciate and make use of the invitation always accorded to make any remarks on this and other matters.

Mr. **Carpenter.** I am not connected with the experiment stations now. As a rule, I think you will agree with me that the fertilizer men try to put pure goods upon the market, and we want you to treat us in the same way. If this method can not be handled by all official chemists, it does not seem fair that it should be introduced—that is, if it can not be used as an official method it ought not to be used as an alternative method to be used by those disposed to do so. I myself have used the method and gotten good results. I think the great trouble has been in getting here and there a bad result. Now and then you will get a result 2 or 3 per cent higher or 2 or 3 per cent lower, and in either case it would work very badly. I think that is the experience of most workers with this method. While in general it gives good results, occasionally it gives bad results.

Mr. **Wheeler**. I would like to ask any others here who have used this method to state their experience.

Mr. **Runyan**. I have had considerable experience with the volumetric method in the last two years, and while the results compared very favorably with the gravimetric method, once in a while I would get a result that was very bad.

Mr. **Van Slyke**. From the evidence that was presented last year or even the year before, accompanied by the evidence presented this year by the reporter, I was of the opinion very strongly that there was scarcely any other method that had been subjected to such critical investigation which gave such satisfactory results; but since listening to the discussion this morning and finding out that there are exceptional cases coming when we least expect them, I am inclined to change my mind somewhat and coincide with the conservative position of the association, and I therefore move that we substitute for the recommendation of the committee the recommendation that this method be continued another year as a provisional method, and that the reporter for next year be asked to continue work on this method.

Mr. **Lindsey**. I would suggest that there be inserted "upon a variety of samples."

Motion as amended to include substitute adopted.

Mr. **Lindsey**. I think every station ought to give this volumetric method a very careful trial.

Mr. **Wheeler**. I would like to say that when the report on phosphoric acid was made there was no objection made to this method. I would say also that the committee has to act just as a jury—upon the evidence presented. The facts presented were all favorable to this method, and hence our recommendation.

The other recommendations of the committee were adopted without discussion or division, and the final form of the recommendations and changes as adopted follow.

Mr. **Huston**. I think it would be the part of wisdom on the part of this association to instruct its reporter to take into consideration the matter of methods of determination of total and so-called available phosphoric acid in basic slag.

Mr. **Myers**. There will undoubtedly be a demand for that during the coming year. Every station east of the Mississippi and throughout the Eastern and Southern country will be confronted by problems necessitating something upon that subject. I think the reporter at least should take hold of it during the coming year. Everything seems to be in chaotic condition. For my part I do not know what should be done with it. I move it be referred to the reporter on phosphoric acid for report at the next meeting.

Adopted.

The **President**. The recommendations adopted by the committee on soil analysis will now be presented.

Mr. Wheeler presented the report of the committee, which was adopted. The recommendations and changes are as given in the report, which is found immediately after the report on soil analysis.

Mr. **Van Slyke**. There was no opportunity given to read papers on dairy products, and I have a paper by Mr. Bartlett.

The **President**. That will now be in order.

(The paper is found immediately following the "Report on dairy products.")

The **President**. The next thing in order is the report on sugar. I received a letter from Dr. Nicholson, the reporter on this subject, several months ago, stating that he understood the meeting would take place earlier in the summer, and he was not aware he had been appointed reporter, and that he was unable to prepare any report.

The next report in order will be that of fermented and distilled liquors.

Mr. **Bigelow**. I regret very much that I have practically nothing to report this year. Samples were sent to 17 chemists, who requested them, with directions for the estimation of glycerol and fusel oil. Not a single report was received, however, and my own results would not warrant the change of any of the methods which have been in use. I have several additions, however, to recommend as provisional methods for the examination of distilled liquors.

PROVISIONAL METHODS FOR THE EXAMINATION OF DISTILLED LIQUORS.

DETERMINATION OF FUSEL OIL.

The apparatus recommended for this determination is Bromwell's modification of Roese's fusel-oil apparatus.

The reagents required are fusel-free alcohol that has been prepared by fractional distillation over caustic soda or caustic potash, rejecting the first and the last three-fifths of the distillate, and diluted to exactly 30 per cent by volume (sp. gr. 0.96541), chloroform, freed from water and redistilled, and sulphuric acid (sp. gr. 1.2857 at 15.6°).

Distill slowly 200 cc of the sample under examination till about 175 cc have passed over, allow the distilling flask to cool, add 25 cc of water, and distill again till the total distillate measures 200 cc. Dilute the distillate to exactly 30 per cent by volume[1] (sp. gr. 0.96541 at 15.6°).

Now prepare a water bath, the contents of which are kept at exactly 15°, and place in it the apparatus (covering the end of the tube with a rubber cap to prevent wetting the inside of the tube) and flasks containing the 30 per cent fusel-free alcohol, chloroform, sulphuric acid, and the distillate diluted to 30 per cent by volume. When the solutions have all attained the temperature of 15°, fill the apparatus to the 20 cc mark with chloroform, drawing it through the lower tube by means of suction, add 100 cc of the 30 per cent fusel-free alcohol and 1 cc of the sulphuric acid, invert the apparatus and shake vigorously for two or three minutes, interrupting once or twice to open the stopcock for the purpose of equalizing pressure. Allow the apparatus to stand ten or fifteen minutes in water that is kept at the temperature of 15°, turning occasionally to hasten the settling of the chloroform, and note the volume of the chloroform. After thoroughly cleansing and drying the apparatus repeat this operation, using the diluted distillate from the sample under examination in place of the fusel-free alcohol. The increase in the chloroform volume with the sample under examination over that with the fusel-free alchol is due to fusel oil, and this difference (expressed in cubic centimeters) multiplied by the factor 0.663 gives the volume of fusel oil in 100 cc, which is equal to the percentage of fusel oil by volume in the 30 per cent distillate. This must be calculated to the percentage of fusel oil by volume in the original liquor.

Example.—A sample of liquor contains 50 per cent of alcohol by volume. The increase in the chloroform volume with the 30 per cent fusel-free alcohol is 1.42 cc. The increase in the chloroform volume with the distillate from the liquor under examination diluted to 30 per cent is 1.62 cc; difference, 0.20 cc. The volume of fusel oil in 100 cc of the 30 per cent distillate, then, is $0.20 \times 0.663 = 0.1326$, and by the proportion 30:50::0.1326:0.221 we obtain the percentage of fusel oil by volume in the original liquor.

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[1] The following is an accurate method for diluting any given alcohol solution to a weaker solution of definite percentage: Designate the volume percentage of the stronger alcohol by V and that of the weaker alcohol by v. Mix v volumes of the stronger alcohol with water to make V volumes of the product. Allow the mixture to stand till full contraction has taken place and till it has reached the temperature of the original alcohol and water and make up any deficiency in the V volumes with water.

Example.—It is desired to dilute a distillate containing 50 per cent of alcohol by volume until it contains 30 per cent. To 30 volumes of the 50 per cent alcohol add enough water to make 50 volumes, or place 150 cc of the distillate in a 250 cc flask, fill to the mark with water, mix, cool, and fill to the mark again.

DETERMINATION OF ALDEHYDS.

(a) *Preparation of reagent.*

Eighty cubic centimeters of a saturated solution of sodium bisulphite are mixed with a solution of 0.12 gram of fuchsin in about 800 cc of water, 12 cc of sulphuric acid added, the solution thoroughly mixed and diluted with water to 1 liter.

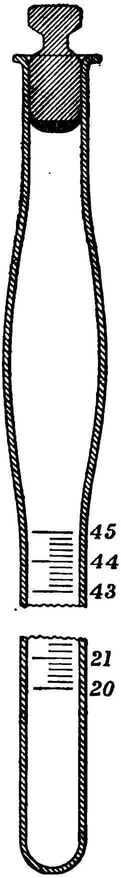

Fig. 1.—Roese's fusel-oil apparatus.

(b) *Determination.*

A portion of the sample is diluted with water or strengthened with aldehyd-free alcohol until it contains 50 per cent of alcohol by volume, and 25 cc of this solution are treated with 10 cc of the reagent and allowed to stand twenty minutes. At the same time 25 cc of a solution of 0.05 gram of acetic aldehyd in 1,000 cc of 50 per cent alcohol are treated in the same manner and allowed to stand the same length of time. The relative intensity of the colors of the two solutions is then determined by means of a colorimeter, and from the figure thus obtained the weight of aldehyd is estimated as acetic aldehyd, and calculated to percentage of the original liquor.

DETERMINATION OF ETHEREAL SALTS.

After the determination of the volatile acids the neutralized distillate is transferred to a flask connected with a reflux condenser, treated with 25 cc of tenth normal sodium hydroxid, and boiled one-half hour. The flask and contents are then cooled, 25 cc of tenth normal hydrochloric acid added, and the excess of acid titrated with sodium hydroxid, using phenolphtalein as indicator. The number of cubic centimeters of tenth normal alkali used in this titration, multiplied by 0.0088, is equal to the weight in grams of ethereal salts (calculated as ethyl acetate) in the volume of liquor taken for the determination.

It might be of interest at this point to notice the apparatus that is most commonly used for the determination of fusel oil.

The first method to be proposed for the estimation of fusel oil in alcoholic beverages which is worthy of serious attention was that of Roese.[1] He made use of the apparatus you see here (fig. 1). It consists of a stoppered cylinder graduated to 0.2 cc from 20 cc to 45 cc and is enlarged to some extent above the 45 cc mark. The entire capacity of the cylinder is from 175 to 200 cc. In the determination the apparatus is filled to the 20 cc mark with chloroform, 100 cc of the sample (diluted with water, or strengthened with fusel-free alcohol, until it contains exactly 50 per cent of alcohol by volume) added, the two liquids thoroughly mixed by agitation, the chloroform allowed to subside and its volume noted. Throughout the operation the temperature of 15° must be maintained. A blank experiment is also conducted, using 100 cc of 50 per cent fusel-free alcohol instead of the diluted sample. The volume of the fusel oil present is equal to about 66.3 per cent of the increase of the chloroform volume with the diluted sample, less that with the fusel-free alcohol.

This apparatus and the method of its application have been modified by Stutzer and Reitmair,[2] Herzfeld,[3] and Windisch[4] until now 30 per cent alcohol are employed instead of 50 per cent, 1 cc of dilute sulphuric acid is added to assist in the separation of the chloroform, and the apparatus itself has assumed the shape you see here (fig. 2). We find here that the graduated portion of the apparatus is made so much smaller in diameter that the error in reading is reduced to 0.01 cc. This form of apparatus, however, is open to two serious objections.

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[1] B. Roese, Ztschr. Spiritusind., 1884, No. 43.

[2] A. Stutzer und O. Reitmair, Rep. anal. Chem., 1886, **6**, 335–341, and 385–391.

[3] H. Herzfeld, Chem. Ztg., 1888, **12**, 410.

[4] C. Windisch, Arb. a. d. kais. Ges. Amt., **5**, 373–393.

First. It is very difficult to fill it exactly to the 20 cc mark without touching the sides of the tube and thus adding an excessive amount—and, indeed, an unknown amount—of chloroform.

Second. The smallness of the stem makes the cleansing of the apparatus slow and inconvenient.

To obviate these objections a further modification has been suggested by Bromwell[1] (fig. 3). This consists in sealing a stopcock tube to the bottom of the chloroform bulb, to facilitate the introduction of the chloroform and the cleansing of the apparatus.

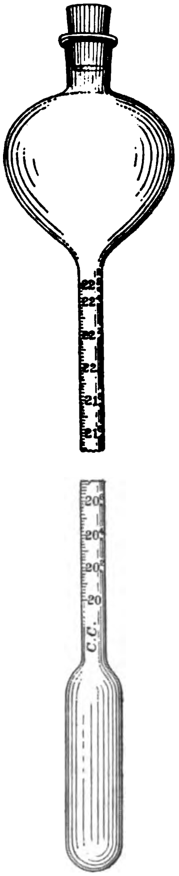

FIG. 2.—Stutzer and Reitmair's fusel-oil apparatus.

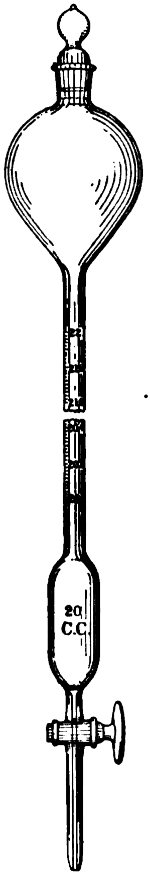

FIG. 3. — Bromwell's fusel-oil apparatus.

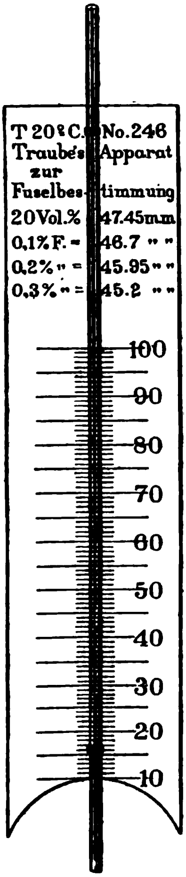

FIG. 4.—Traube's capillarimeter.

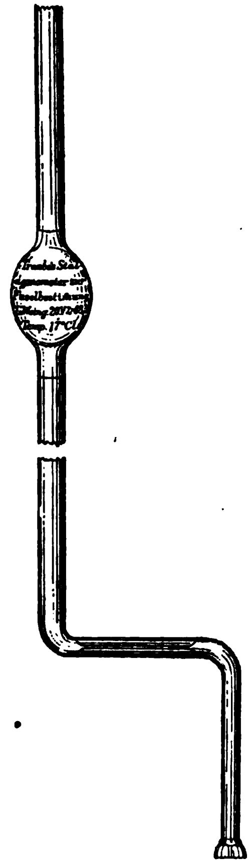

FIG. 5.—Traube's stalagmometer.

The other apparatus to which I wish to call your attention are Traube's capillarimeter and stalagmometer, whose application depends on the influence of fusel oil on the viscosity of alcoholic liquors. The advantages claimed for the forms of apparatus are the convenience and rapidity with which they may be used. In each case the alcohol is diluted to 20 per cent by volume. The first of these, in point of time as well as in point of value, is the capillarimeter (fig. 4). This consists of a capillary tube mounted on a porcelain scale. The scale is held in position by a clamp that may be raised and lowered by a screw until these two points (a and b) just touch the surface of the sample (diluted to 20 per cent by volume), which is contained in a dish or beaker below the apparatus. The sample is drawn to the top of the capillary tube several times by means of suction, and the height of the liquid in the tube is read on the porcelain scale. This reading is corrected for temperature, if not made at the temperature for which the instrument was graduated, and subtracted from the height of the column with 20 per cent fusel-free alcohol, which gives a figure from which the volume of fusel oil may readily be calculated by means of data given on each instrument.

---

[1] William Bromwell, Bull. 47, p. 100.

The other apparatus of Traube's to which I referred is the stalagmometer (fig. 5). This consists of a bent bulb tube with the horizontal section and the point capillary. It is filled with the sample under examination (diluted to 20 per cent by volume), the number of drops between the two points of graduation above and below the bulb being counted. In a volume of the diluted sample, equal to 100 drops of 20 per cent fusel-free alcohol, each 1.6 drops in excess of that number indicates the presence of 0.1 per cent of fusel oil. The temperature for which the apparatus is graduated and a temperature correction are stated on each instrument.

AMENDED AND ADOPTED REPORT OF THE COMMITTEE ON RECOMMENDATIONS IN RELATION TO LIQUORS.

It is recommended—

(1) That the Röse method for fusel oil as modified by Stutzer and Reitmair, with Bromwell's apparatus, be adopted as a provisional method.

(2) That the methods described by the reporter for aldehyds and esters be adopted as provisional ones.

(3) That any further work in the line of liquors be discontinued until called for by the association.

(4) That methods for detecting the adulteration of foods, so far as such are not provided for in connection with other reporters, be referred to the reporter on spirituous liquors.

H. J. Wheeler,
For the Committee on Recommendations of Reporters.

Mr. Winton. It appears that this reporter on liquors has had an easy time of it, although he has distributed bottles, but no one seems to have had any time for analytical work. I do not think he has had his share of the work. It is very evident that a work of that nature is carried on to a great extent. There hardly seems to be work enough for the reporter. As I understand it, this examination of liquors pertains largely to the detection of adulterants. We know that the Department of Agriculture for a number of years past has done valuable work in examining foods for adulterants. Their publications are regarded as valuable works on this subject. At some of the agricultural stations work in this line has been carried on. It seems to me very proper that we should have a reporter for all this. I would therefore move that the duty of the reporter on fermented and distilled liquors be increased, and that he may be made the reporter of methods for the detection of adulterants in food. Of course a great deal of that work is carried on by other reporters. The reporter on dairy products considers the matter of detecting adulterants in milk, cheese, and butter, etc., but there is no need of their work interfering.

Mr. Hird. In regard to the recommendation of the use of this method of determining fusel oil: There is perhaps at the most in the samples of liquors but two to three tenths of 1 per cent, so that the use of the apparatus requires considerable care. Where the method is accurately carried out and the specific gravity is taken, as it should be, the method assures great accuracy. In all cases where this method is used, I might state that if carried out as it should be it insures great accuracy, and that if the operator in making use of the same fails to secure the results that should be secured he must not blame the method.

The **President**. The question arises whether this matter of increasing the duty of the reporter on liquors is proper.

Mr. **Lindsey**. I do not know how we could get out of the matter, unless we refer it to the committee on recommendations.

Mr. **Myers**. I move that the matter be referred to the committee on recommendations.

Mr. **Frear**. I would like to say regarding food adulterations that I have had a little work to do in that line. I wish we had had a reporter on the subject five years ago. I would be heartily glad if the association in some form would provide for beginning work in this direction. It seems to me a proper subject for the association to undertake, since it is a matter of more than ordinary importance.

Mr. **Myers**. I hope the motion to get it into some kind of shape will go forward. I am perfectly willing, however, to accept anything else, so we get it into proper shape.

The **President**. Recommendations are referred in regular order, and it seems to me this would be referred without any direct motion. If there is no objection, the recommendations are referred to the committee.

Mr. **Myers**. It is now half past 12, and I think we had better take a recess until 2 o'clock. I move, therefore, that we take a recess until 2 o'clock.

Objection to this motion, and point raised that it would be better to stay in session and finish proceedings.

Motion defeated.

The **President**. The report on tanning materials is now in order.

Reporter not present.

Mr. **Yocum**. In the absence of the reporter I may be allowed to say that we feel deeply indebted to this association. The publications of the association have been sent around among the tanners and extract manufacturers, and if to-day an analysis is made the extract man is not satisfied unless it is the method printed in the association's records; neither is the tanner. I can not go further than that, beyond saying we buy a good deal of extract, and it amounts to considerable, looking at it entirely from a commercial point of view. I feel greatly interested in that line from that point of view, and am deeply indebted to this association for having brought it into the position where tanner and extract man have got to come down and use these analyses as the basis on which the extracts have to be sold and bought. Seventy-five per cent of the extract bought is paid for on the analysis, and the analysis is made by the official methods.

Messrs. Krug, Yocum, Haley, and Carr presented recommendations in respect of tanning methods, which were referred to committee on recommendations.

The committee recommended the adoption of the proposed changes.

Mr. **Wiley**. I move that the report of the committee on recommendations made on tanning be accepted as the action of the association.

Adopted.

The recommendations as adopted follow:

AMENDED AND ADOPTED REPORT OF THE COMMITTEE ON RECOMMENDATIONS IN RELATION TO METHODS FOR THE ANALYSIS OF TANNING MATERIALS.

(1) *Preparation of sample.*

Barks, woods, leaves, and similar tanning materials should be ground to such a degree of fineness that they can be thoroughly extracted.

Extracts must be heated to 50° C., well shaken, and allowed to cool slowly to room temperature.

(2) *Quantity of tanning material.*

In the case of barks, woods, leaves, etc., use such an amount of the material as to give about one gram of total solids per 100 cc of solution, and extract in a Soxhlet or similar apparatus. In the case of extracts, weigh 20 grams dilute with water at 80°, cool slowly to 20°, and make up to a liter.

(3) *Determination of moisture.*

Dry 5 grams of the sample in a flat-bottomed dish at the temperature of boiling water until the weight becomes constant.

(4) *Determination of total solids.*

Shake the solution and without filtering immediately measure out 100 cc with a pipette. Care must be taken to keep the solution at 20°. Evaporate in a weighed dish and dry to constant weight at the temperature of boiling water. The dishes in which the drying is conducted should be covered while they are in the oven in order to prevent loss.

(5) *Determination of soluble solids.*

Filter about 125 cc of the solution (at 20°) through a double-folded filter (S. and S. No. 590, 25 cm), returning the filtrate through the filter twice. Evaporate 100 cc as before.

(6) *Determination of tanning substances.*

Prepare 20 grams of hide powder by shaking for five minutes with 250 cc of water and straining through linen. Repeat the operation three times. Finally remove as much water as possible by squeezing in a press. Transfer the pressed hide powder to a covered dish and weigh. Dry to constant weight, at 100°, a portion approximately equal to one-fourth of the whole. To 200 cc of the original unfiltered solution (at 20°), add the remainder of the hide powder, and shake for ten minutes. Add 5 grams of barium sulphate free from soluble salts and shake again for one minute. Filter immediately through a folded filter (S. and S. No. 590, 15 cm), returning the first 25 cc. Evaporate 100 cc as before. The weight of the residue must be corrected for the dilution caused by the water contained in the hide powder. The shaking must be done in some form of mechanical shaker. The simple machine used by druggists, and known as the milk shake, is recommended.

(7) *Testing the hide powder.*

(*a*) Shake 10 grams of the hide powder with 200 cc of water for five minutes; filter through muslin or linen; squeeze out thoroughly by hand; collect the hide powder, and repeat the operation twice with the same quantity of water. Pass the last filtrate through paper until a perfectly clear liquid is obtained. Evaporate 100 cc of the final filtrate in a weighed dish; dry at 100° until the weight is constant. If the residue amount to more than 10 milligrams the sample should be rejected. The hide powder must be kept in a dry place and tested once a month.

(*b*) Prepare a solution of pure gallotannic acid by dissolving 5 grams in 1 liter of water. Determine the total solids by evaporating 100 cc of this solution and drying to constant weight. Treat 200 cc of the solution with hide powder exactly as described in paragraph 6. The hide powder must absorb at least 95 per cent of the total solids present. The gallotannic acid used must be completely soluble in water, alcohol, acetone, and acetic ether, and should contain not more than 1 per cent of substances not removed by digesting with excess of yellow murcuric oxid on the steam bath for two hours.

(8) *Testing the nontannin filtrate.*

(*a*) For tannin: Test a small portion of the clear nontannin filtrate with a few drops of a 10 per cent solution of gelatine (Nelson's). A cloudiness indicates the presence of tannin, in which case the determination must be repeated, using 25 grams of hide powder instead of 20 grams.

(*b*) For soluble hide: To a small portion of the clear nontannin filtrate add a few drops of the original solution, previously filtered to remove reds. A cloudiness indicates the presence of soluble hide due to incomplete washing of the hide powder. In this case repeat the determination with perfectly washed hide powder.

Mr. Frear, the president elect, announced the committees and reporters for next year. The names of the members designated to act will be found in the list of officers. The president called for the report of the committee on pure-food legislation.

Mr. WILEY. I am sorry the committee has no formal report to make, and the fault is entirely mine. Owing to absence I neglected to bring the matter definitely before the other members of the committee, and the result is that no action has been taken. I beg the indulgence of the association for not having carried out its will, and ask that the committee be continued for another year.

The request for the continuation of the committee was granted.

The president called for the report of the committee on abstracts.

The committee presented the following report:

REPORT OF THE COMMITTEE ON ABSTRACTS.

MR. PRESIDENT AND MEMBERS OF THE ASSOCIATION: Your committee has the honor to make the following report. As soon as practicable after the appointment of the committee the work was organized and gotten under way, and the following assignment of work made:

E. W. Allen: Chem. Centralbl., Chem. Ztg., Ann. Chim. et Phys., Bull. Soc. Chim. Paris, Forsch. Geb. agr. Phys.; and the abstract part of Jour. Chem. Soc., Analyst, Ztschr. anal. Chem., Ztschr. angew. Chem., and Ber. deut. chem. Ges.

J. L. Beeson: Work on sugar analysis published in the French language.

W. D. Bigelow: Methods for fermented and distilled liquors.

B. W. Kilgore: Analyst, Chem. News, and Ztschr. anal. Chem.

W. H. Krug: Work on sugar analysis published in the German language, methods for tannin; and Amer. Jour. Sci., Amer. Jour. Pharm., Jour. Franklin Inst., and Pharm. Jour.

C. L. Parsons: Ztschr. anorgan. Chem., Ztschr. angew. Chem., and Amer. Chem. Jour.

H. J. Patterson: Jour. Amer. Chem. Soc., Jour. Chem. Soc. (London), Sci. News, and Boston Jour. Chem.

A. M. Peter: Jour. Soc. Chem. Ind., Ber. deut. chem. Ges., and Liebig's Ann. Phys. und Chem.

F. W. Woll: Landw. Vers.-Stat., Ztschr. Nahr.-Untersuch. und Hyg., Ztschr. physiol. Chem., and Milch-Ztg.

The limited number of journals within the reach of some of the members rendered it impossible to make an entirely equal division of the work. An effort was made, as far as the journals at the disposal of the committee permitted, to make an assignment by subjects.

With the exception of those to whom subjects were assigned, the abstracts were confined to the original articles appearing in their journals, omitting any abstracts which might be included in these journals. It was urged that the abstracts be sent in regularly and as promptly as possible, as the Office of Experiment Stations would cooperate with the association and would undertake to a considerable extent to follow up the principal abstract journals and otherwise supplement the work which the committee might be unable to do.

In the interest of uniformity the following suggestions were sent out by the chairman:

SUGGESTIONS FOR COMMITTEE ON ABSTRACTS, 1895–96.

The abstract should state (1) the English translation of the title; (2) the author; (3) the reference; (4) a concise summary of the contents of the article, which should be full enough to bring out the main points; and (5) the name of the abstracter.

In giving the reference, state the name of the periodical (using full and intelligible abbreviations, if preferred), the volume number in figures, the year, the number within the volume (No., heft, fasc., etc.), and the pages (beginning and ending of article), with the number of figures. The abstracts of chemical methods in Experiment Station Record will serve for illustration.

Govern the length of the abstract by the importance and value of the article, as far as practicable. Articles not deemed worthy of abstracting would be listed by title, thus: "A new method for the quantitative determination of glucose, F. GAND (Rev. Internat. Falsif., 8 (1895), No. 10, p. 173)." Usually a few words of explanation of the character of the article may be added with advantage.

When the abstract is made from an abstract instead of from the original article, give reference to both the original and the abstract, thus: (Chem. Ztg., 18 (1894), No. 58, pp. 601–603; abs. in Chem. Centbl., 1894, II, No. 3, p. 105).

Either abstract or list everything bearing on methods or apparatus in the journals assigned to you. This is very important, in order to make our work complete as far as it goes.

Exceptions.—(1) Where journals containing abstracts have been assigned to you, confine yourself to the original papers, as the abstracts have been provided for otherwise.

(2) Do not abstract or list methods for sugar, tannin, and fermented and distilled liquors, as these will be looked after by Messrs. Beeson, Krug, and Bigelow.

The work of the committee began with the issues of journals subsequent to September 1, 1895, where it was discontinued by the preceding committee. The publication of the abstracts began in Experiment Station Record, Vol. VII, No. 5, and has continued through each number up to Vol. VIII, No. 3, now in press. The printed work of the committee has occupied over 75 pages in the Record. There remain a considerable number of abstracts received since the last Record went to press, which will be included in the next number. It is believed that the work, in most lines at least, is well up to date.

The committee desires to acknowledge the efficient assistance rendered by Mr. W. H. Beal, of the Office of Experiment Stations, who has contributed many abstracts on fertilizers and soils.

E. W. ALLEN,
J. L. BEESON,
W. D. BIGELOW,
B. W. KILGORE,
W. H. KRUG,
H. J. PATTERSON,
W. L. PARSONS,
A. M. PETER,
F. W. WOLL,
Committee.

The president called for the report of the committee on resolutions. The committee presented the following report:

Resolved, That this association has heard with great sorrow of the death of Hon. Edwin Willits, late Assistant Secretary of Agriculture; that during the time Mr. Willits was Assistant Secretary we found him a true and helpful friend of our association, ready at all times to assist us with word and deed. After he returned to private life he did not lose his interest in our welfare, nor did he fail to attend our meetings. We remember with special pleasure his presence at our last meeting, and the words of cheer and advice which he gave us. His manly life and devotion to duty will ever be to us a support and inspiration to greater endeavor.

That a copy of this resolution be printed as a part of our proceedings, and that one be sent to the family of our dead friend.

B. W. KILGORE.
H. A. HUSTON.
H. W. WILEY.

Mr. **MYERS**. I move that the association extend to the Secretary of Agriculture our most hearty thanks for the courtesy he has extended us in publishing our reports and in providing facilities for conducting our meetings.

Mr. **HUSTON**. I think we should adopt a resolution of thanks to the National Museum.

The **PRESIDENT**. Both resolutions will be presented together. Both are unanimously adopted.

Calls for a speech from the president.

The **PRESIDENT**. I am very thankful for the very kind and courteous manner in which the presiding officer has been treated by all the members of the association.

Motion to adjourn *sine die* carried.

OFFICERS, REPORTERS, AND COMMITTEES OF THE ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS FOR THE YEAR 1897.

PRESIDENT.

WILLIAM FREAR, State College, Pa.

VICE-PRESIDENT.

A. L. **WINTON**, Washington, D. C.

SECRETARY.

H. W. **WILEY**, Washington, D. C.

ADDITIONAL MEMBERS OF EXECUTIVE COMMITTEE.

Mr. B. W. **KILGORE**, Raleigh, N. C.
Mr. **ARTHUR GOSS**, Mesilla Park, N. Mex.

REPORTERS.

Phosphoric acid.—Mr. H. B. McDonnell, College Park, Md.
Nitrogen.—Mr. J. P. Street, New Brunswick, N. J.
Potash.—Mr. A. L. Winton, New Haven, Conn.
Soils and ash.—Mr. A. Goss, Mesilla Park, N. Mex.
Dairy products.—Mr. L. L. Van Slyke, Geneva, N. Y.
Foods and feeding stuffs.—Mr. J. B. Lindsey, Amherst, Mass.
Fermented and distilled liquors.—Mr. W. D. Bigelow, Washington, D. C.
Sugar.—Mr. L. W. Wilkinson, New Orleans, La.
Tannin.—Mr. B. D. Westenfelder, Cincinnati, Ohio.

ASSOCIATE REPORTERS.

Phosphoric acid.—Mr. L. H. Merrill, Orono, Me.
Nitrogen.—Mr. R. J. Davidson, Blacksburg, Va.
Potash.—Mr. C. H. Jones, Burlington, Vt.
Soils and ash.—Mr. Harry Snyder, St. Anthony Park, Minn.
Dairy products.—Mr. C. L. Penny, Newark, Del.
Foods and feeding stuffs.—Mr. F. W. Morse, Durham, N. H.
Fermented and distilled liquors.—W. S. Sweetser, State College, Pa.
Sugar.—Mr. Samuel Avery, Lincoln, Nebr.
Tannin.—Mr. John H. Yocum, New York, N. Y.

ABSTRACT COMMITTEE.

Mr. E. W. Allen, Washington, D. C., chairman.
Mr. F. W. Morse, Durham, N. H.
Mr. W. D. Bigelow, Washington, D. C.
Mr. J. T. Anderson, Auburn, Ala.
Mr. B. H. Hite, Morgantown, W. Va.
Mr. W. H. Krug, Washington, D. C.
Mr. B. W. Kilgore, Raleigh, N. C.
Mr. F. W. Woll, Madison, Wis.

COMMITTEE ON PURE FOOD LEGISLATION.

Mr. H. W. Wiley, Washington, D. C., chairman.
Mr. H. A. Huston, Lafayette, Ind.
Mr. John A. Myers, Morgantown, W. Va.
Mr. A. S. Mitchell, Milwaukee, Wis.

CONSTITUTION OF THE ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS.

(1) This association shall be known as the Association of Official Agricultural Chemists of the United States. The objects of the association shall be (1) to secure uniformity and accuracy of the methods, results, and modes of statements of analysis of fertilizers, soils, cattle foods, dairy products, and other materials connected with agricultural industry; (2) to afford opportunity for the discussion of matters of interest to agricultural chemists.

(2) Analytical chemists connected with the United States Department of Agriculture, or with any State or national agricultural experiment station or agricultural college, or with any State or national institution or body charged with official control of the materials named in section 1, shall alone be eligible to membership; and one such representative for each of these institutions or boards, when properly accredited, shall be entitled to enter motions or vote in the association. Only such chemists as are connected with institutions exercising official fertilizer control shall vote on questions involving methods of analyzing fertilizers. Any person eligible to membership may become a member at any meeting of the association by presenting proper credentials and signing this constitution. All members of the association who lose their right to such membership by retiring from positions indicated as requisite for membership shall be entitled to become honorary members, and to have all privileges of membership save the right to hold office and vote. All analytical chemists and others interested in the objects of the association may attend its meetings and take part in its discussions, but shall not be entitled to enter motions or vote.

(3) The officers of the association shall consist of a president, a vice-president, and a secretary, who shall also act as treasurer; and these officers, together with two other members to be elected by the association, shall constitute the executive committee. When any officer ceases to be a member by reason of withdrawing from a department or board whose members are eligible to membership, his office shall be considered vacant, and a successor may be appointed by the executive committee, to continue in office till the annual meeting next following.

(4) There shall be appointed by the president, at the regular annual meeting, a reporter and associate reporter for each of the subjects to be considered by the association.

It shall be the duty of these reporters to prepare and distribute samples and standard reagents to members of the association and others desiring the same; to furnish blanks for tabulating analyses, and to present at the annual meeting the results of work done, discussion thereof, and recommendations of methods to be followed.

(5) The special duties of the officers of the association shall be further defined, when necessary, by the executive committee.

(6) The annual meeting of this association shall be held at such place as shall be decided by the association, and at such time as shall be decided by the executive committee, and announced at least three months before the time of meeting.

(7) No changes shall be made in the methods of fertilizer analyses, except by unanimous consent, until an opportunity shall have been given all official chemists having charge of fertilizer work to test the proposed changes.

(8) Special meetings shall be called by the executive committee when in its judgment it shall be necessary, or on the written request of five members; and at any meeting, regular or special, seven enrolled members entitled to vote shall constitute a quorum for the transaction of business.

(9) The executive committee will confer with the official boards represented with reference to the payment of expenses connected with the meetings and publication of the proceedings of the association.

(10) All proposed alterations or amendments to this constitution shall be referred to a select committee of three at a regular meeting, and after report from such committee may be adopted by the approval of two-thirds of the members present entitled to vote.

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BULLETIN NO. 50.

U. S. DEPARTMENT OF AGRICULTURE.
DIVISION OF CHEMISTRY.

COMPOSITION OF MAIZE
(INDIAN CORN),

INCLUDING THE

GRAIN, MEAL, STALKS, PITH, FODDER, AND COBS.

COMPILED CHIEFLY FROM THE RECORDS OF THE DIVISION OF CHEMISTRY,

BY

H. W. WILEY,
Chemist of the Department of Agriculture.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1898.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF CHEMISTRY,
Washington, July 25, 1898.

SIR: I transmit herewith, for your inspection and approval, the manuscript of Bulletin No. 50 of this division, relating to the composition of maize in all its parts.

The material contained in this bulletin has been compiled from the records, mostly recent, of the investigations of the Division of Chemistry of the composition of maize. Some of the data have also been derived from the researches of the agricultural colleges and experiment stations. No attempt has been made to give a complete summary of the work which has been done in this country on this product, but simply to present, in a condensed form, the more important data in connection with its composition.

The immediate object of the preparation of this bulletin is to present it to the Third International Congress of Applied Chemistry, in Vienna. There is in Europe a considerable degree of prejudice against the use of Indian corn as a human food, and its value as a cattle food, both in respect of its grain and its stover, is not fully appreciated. It is believed that this brief summary of our present knowledge on the subject will prove advantageous both to the maize growers of this country and to the food consumers of Europe.

Respectfully,

H. W. WILEY,
Chief of Division.

Hon. JAMES WILSON, *Secretary.*

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THE COMPOSITION OF MAIZE (INDIAN CORN) AND SOME OF ITS PRINCIPAL PRODUCTS.

Maize is the most important crop cultivated in the United States. The average area in maize for the ten years ended December 31, 1897, was 75,061,112 acres (30,376,815.86 hectares), and the average production of the grain of maize for the same period was 1,844,951,786 bushels (650,157,446.52 hectoliters).

Maize is not only valuable for the grain which it produces, but the fodder, stalk, or stover, has a high commercial value as feeding material and for other purposes. It is true that the greater part of the fodder at the present time is left upon the fields to be burned before the planting of the next crop. In the older parts of the country, however, the fodder is now carefully preserved and is found to be equally as valuable as the grain when prepared and fed in the proper manner. The purpose of this paper is to present, in a condensed form, some of the results of the extensive chemical examinations which have been made in the laboratory of the Department of Agriculture at Washington on the composition of Indian corn in its entirety, and especially in relation to some of its principal products.

In all parts of the country maize forms a considerable percentage of the food of our people, and especially is this true in the Southern States, where Indian corn bread, among parts of the population, is the chief bread food used. In various other forms, as hasty pudding (mush) and other methods of preparation, it enters largely into our dietaries. Although important as a human food, the principal use of maize is as feed for live stock; and it is also used for the manufacture of starch, of glucose, and of whisky and alcohol. On account of its great importance, a somewhat careful study of its composition is justifiable.

COMPOSITION OF THE GRAINS.

For the typical samples of grain grown in the United States and collected at the World's Columbian Exposition at Chicago the following represents the constitution:

Weight of 100 kernels...grams..	38.979	Crude fiber.............per cent..	1.71
Moisture.............per cent..	10.93	Ash........................do....	1.36
Proteids..................do....	9.88	Carbohydrates other than crude fiber...............per cent..	71.95
Fat and oil...............do....	4.17		

The following table represents the maxima, minima, and means of the constituents of maize collected in all parts of the world:

Table of maxima, minima, and means of constituents of maize.

Kind of sample.	Weight of 100 kernels.	Moisture.	Proteids.	Ether extract.	Crude fiber.	Ash.	Carbohydrates.
Domestic corn:	*Grams.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Maxima	*a* 48.312	*b* 12.32	*a* 11.55	*a* 5.06	*b* 2	*b* 1.55	*b* 75.07
Minima	*c* 10.608	*b* 9.58	*b* 8.58	*b* 2.94	*d* 1	*a* 1.19	*a* 68.97
Means	38.979	10.93	9.88	4.17	1.71	1.36	71.95
Foreign corn:							
Maxima	*e* 46.487	*f* 12.60	*g* 11.55	*e* 4.85	*f* 2.20	*g* 1.80	*e* 71.85
Minima	*f* 18.428	*e* 10.43	*e* 9.80	*f* 4.02	*e* 1.57	*f* 1.26	*g* 58.02
Means	28.553	11.71	10.72	4.51	1.87	1.54	69.65
Means of samples from the United States exhibited at the Columbian Exposition (18 analyses)	38.979	10.93	9.88	4.17	1.71	1.36	71.95
Means of foreign samples exhibited at the Columbian Exposition (2 analyses)	28.553	11.71	10.72	4.51	1.87	1.54	69.65
Means of former analyses of the Department of Agriculture:							
United States	*h* 36.747	*i* 10.04	*j* 10.39	*i* 5.20	*i* 2.09	*j* 1.55	*i* 70.69
Northern States	37.320	9.98	10.64	5.11	1.41	1.54	71.32
Southern States	40.659	8.96	10.95	4.94	1.72	1.37	72.06
Middle West	32.457	12.33	10.89	4.97	2.22	1.43	68.16
Far West	37.528	9.50	10.43	5.30	2.47	1.55	70.75
Pacific Slope	27.900	9.78	8.14	6.40	2.07	1.48	72.13
Jenkins and Winton (208 analyses)	....	10.90	10.50	5.40	2.10	1.50	69.60
König (mean composition of samples from various localities):							
Miscellaneous origin (137)	....	13.35	9.45	4.29	2.29	1.29	69.33
Italian samples (24)	....	13.13	10.26	3.84	2.38	1.95	67.72
American samples (80)	....	10.02	10.17	4.78	1.67	1.40	68.63
Dent corn (149)	....	10.14	9.36	4.96	2.21	1.47	68.65
Sugar corn (27)	....	8.70	11.43	7.79	2.86	1.81	62.76
Southeastern Europe (19)	....	14.53	9.42	4.13	2.34	1.39	69.37
Southwestern Europe (8)	....	12.47	8.84	5.80	4.16	2.06	65.79

a Kentucky. *c* Wisconsin. *e* New South Wales. *g* Argentine Republic. *i* 114 analyses.
b Indiana. *d* New Hampshire. *f* Bulgaria. *h* 1,211 analyses. *j* 202 analyses.

Comparing the means of the analyses of American samples with those of foreign origin, we are struck with the excess of moisture in the foreign samples. In those from southwestern Europe are found 4 per cent more moisture than in samples of domestic origin. Among the samples grown in the United States, those in the Middle West, viz, Iowa, Missouri, Nebraska, etc., contain the largest amount of moisture, while those grown in the arid region have the smallest amount. Of the domestic samples exhibited at the World's Fair it was found that the mean content of water was 10.93 per cent, nearly 1 per cent higher than the mean of former analyses of the Department. The weight of 100 kernels was a little more than that before found, and this is not a surprising fact, inasmuch as it would be natural for exhibitors to send not only the largest ears but also the largest grains to the Exposition. The percentage of proteids in the domestic World's Fair samples was surprisingly low, being about 0.75 per cent less than was found in the samples examined a few years ago. On the other hand, the percentage of carbohydrates was about one point higher than that obtained in the former work. In the above table will be found a convenient comparison of the means of maize analyses from all parts of the world.

The typical American maize has approximately the following composition:

Weight of 100 kernels.....grams..	38.00	Crude fiber..............per cent..	1.75
Moisture................per cent..	10.75	Ash........................do....	1.50
Proteids....................do....	10.00	Carbohydrates other than crude fiber................per cent..	71.75
Oil.........................do....	4.25		

PROTEIDS OF THE KERNELS.

The maize proteids have been studied by Chittenden and Osborne, who divide them as follows:

Globulins: Unnamed, myosin, vitellin.

Albumins: (1) Existing in small quantities, (2) existing in small quantities.

Zeins: (1) Soluble in alcohol, (2) insoluble in alcohol.

Of these bodies the albumins have not been obtained sufficiently pure to give the final data of composition. The other proteids have the following composition:

Composition of maize proteids.

Constituent elements.	Myosin.	Vitellin.	Unnamed globulin.	Soluble zeins.	Insoluble zeins.
	Per cent.	*Per cent.*	*Per cent*	*Per cent.*	*Per cent.*
Carbon	52.66	51.71	52.38	55.28	55.15
Hydrogen	7.02	6.85	6.82	7.27	7.24
Nitrogen	16.76	18.12	15.25	16.09	16.22
Sulphur	1.30	.86	1.26	.59	.62
Oxygen	22.26	22.46	24.29	20.77	20.77

The relative quantities of the different proteids have been lately definitely determined, but the two zeins comprise by far the largest part. As a result of Osborne's latest determination, it may be stated that the mean percentage of nitrogen in maize proteids is 16.057, equivalent to the factor 6.23. This is so near the old factor 6.25 as to make unnecessary any correction in the percentages of total proteids given above.

VARIATIONS IN COMPOSITION.

Certain special varieties of early maturing maize, or sweet maize intended for table use when in the partially ripe state, are characterized by the large quantity of sugar which they contain, especially when the starch is still soft. In the earlier investigations of the Department it was noticed that the percentage of crude fiber was somewhat larger in varieties grown in the West and South than in those from the North and East, and, further, that in samples grown on the Pacific coast there was a slight deficiency of proteids. Further investigations, however, would be necessary to determine whether or not this apparent increase in fiber be due to the accidental constitution of the sample or to the real influence of the soil and climate. It is reasonable to expect that in some slowly maturing varieties, such as would grow in the Southwest and South, the percentage of fiber in the grain would be greater than in the more rapidly maturing varieties growing in the East and North.

In the case of sugar or sweet corn Richardson found the mean composition of 19 samples to be the following:

	Per cent.		Per cent.
Moisture	8.44	Ash	1.97
Ether extract	8.57	Proteids	11.48
Crude fiber	2.82	Carbohydrates, other than fiber	66.72

This analysis shows that the sweet corn has a considerably larger percentage of oil than the field varieties, and there is a larger percentage of sugar in the carbohydrates.

A study of all the analyses which have been made in this division reveals the fact that maize is one of the most invariable of the cereals, maintaining under the most different climatic conditions a most remarkable uniformity of composition, and varying chiefly in the size, color, and general physical characteristics of its kernels rather than in their composition. For detailed information in regard to the variations and general characteristics of different varieties of maize grown in different localities, Bulletins 1 and 45 of this division may be consulted.

MILLING OF MAIZE—QUALITIES OF MEAL.

The flour made from Indian corn is known in this country usually as corn meal. There are many different methods of preparing it. The simplest, and one of the most prevalent until within a few years, consisted in grinding the kernels between stones and using the whole meal, coarsely sifted, thus produced. Very large quantities of corn meal prepared in this way are still used throughout all parts of the country, especially in the Southern States. It is evident that this meal would have nearly the same composition as the kernels from which it is prepared. A finer grade of Indian-corn flour is produced by grinding as above indicated and bolting to remove a large portion of the bran.

The flour thus obtained differs only from that first described in having a smaller content of fiber and mineral matters, due to the removal of all or a portion of the bran by bolting. On account of the high percentage of oil in the germ of Indian corn, and by reason of its hygroscopic character, the flour thus prepared is apt to become rancid or moldy. To prevent this change and also to secure a more palatable grade of flour, the modern improved processes of grinding and preparing Indian corn have been introduced. Following is the description of the process of preparing the flour from Indian corn as practiced by one of the largest mills in this country.

The Indian corn is passed through a machine called a degerminator, which breaks the grain and loosens the germ, but does not separate it. The separation is made by means of bolting cloths and currents of air. After the germ and hull are removed the corn is ground between iron rolls properly corrugated. The meal is again submitted to the process of bolting and purification by currents of air and the refined product is the granular meal. The offal consists of the hull, germ, floury particles, and some of the flinty portion of the corn which is lost by the process not being sufficiently perfect to remove it and include it in the granular meal. The offal thus removed constitutes from 30 to 35 per cent of the weight of the corn, depending upon the conditions of the grain. Artificial heat is used in this method of manufacture. It insures better results, and the meal will keep longer. This granular meal is not in favor in the Southern States. They prefer a soft meal, made in the old way.

Aside from the method of manufacture there are two distinct kinds of corn meal in the United States distinguished by color, viz, the white and the yellow. White corn makes a flour which in color is quite like the flour made from wheat. On the other hand, yellow corn makes a flour of a rich yellow, which is highly prized in some quarters on account of imparting its color to the bread made therefrom. When prepared in the same way there is probably but little difference in the nutritive value and palatableness of these two varieties.

In Europe, as has been mentioned before, Indian corn is not considered fit for the manufacture of bread for the use of man. This prejudice seems quite baseless when we consider the very extensive use of this material for bread making in this country and the high nutritive properties which it possesses. With a diet of Indian-corn bread and pork the workmen of this country are capable of enduring the greatest fatigue and performing the greatest amount of physical labor. The high nutritive value of Indian-corn bread was well illustrated in a marked degree in the military service during the civil war between the States. Both experience and chemical analysis show that there is little, if any, difference between the nutritive properties of bread made from wheat and that from the whole Indian corn deprived only of the coarsest parts of the bran.

MICROSCOPIC CHARACTER OF MEAL.

Maize flour is of a yellowish or white color and rough to the touch. The starch is in grains of a tolerably uniform volume. The minimum diameter appears to be about 6 micromillimeters, while the largest may reach as much as 17 micromillimeters. The greater part have diameters of from 13 to 15 micromillimeters. The starch granules are polyhedric in shape when they come from the external zone. They are of rounded shape, on the contrary, in the floury zone. The upper face appears to be somewhat spherical. The hilum is punctiform and sometimes stellated. The concentric layers are well marked and the fracture is most frequently from the exterior toward the interior. Heated in water at 62.5° the starch granules swell up and become deformed, except a few—especially the smaller ones—which resist the action of water at that temperature.

In maize, as in oats, the starch granules are polyhedric, but the resemblance extends no further, the maize granules being larger and never becoming agglomerated and forming compound particles. Their action also on polarized light is characteristic. The starch granules of maize depolarize the light and present a black cross very marked and very distinct when the field is obscure. This cross persists for a long time when the field is illuminated little by little, and it is distinguished much more easily and with an illumination much more pronounced than that which suffices to extinguish this phenomenon in other common starches. Nevertheless, this cross is not long visible when the field is fully illuminated. With the selenite plates, by preference working on a neutral field, the grains of starch of the maize are seen to be colored red, with a green cross, or reciprocally. This coloration is very brilliant.

If the starch granules be treated with caustic potash, there is found in the midst of the débris a number of amorphous cellules of the amylaceous tissue irregularly arranged, in which may sometimes be distinguished a final residue of the protoplasmic matter which surrounds the starch granules.

The glutinous cells of maize resemble those of rye. They are disposed in a single row, quadrangular, a little rounded on the angles and much thicker on the exterior side than on the others. The starch cells of maize are easily distinguished from those of the rye by their form and by their action on polarized light.

COMPOSITION OF FINE MEAL.

The composition of the ordinary Indian-corn meal produced by grinding the whole grain and removing only the coarser bran is, as has already been said, practically that of the whole grain itself. Analyses of the refined Indian-corn flours show that they differ chiefly from the whole grain in having a smaller content of fat, fiber, and proteids and a correspondingly higher content of carbohydrates. The low content of proteids is due to the fact that the germ and the finer envelopes are rich in proteid matter and are removed in the process of milling. The low content of oil is due, of course, to the fact that the germ has been extracted. The content of fiber, while low compared with the whole grain, is high compared with a high-grade wheat flour.

A description of the samples analyzed and their composition follows:

Composition and description of Indian-corn flours.

[Purchased for United States Army by Maj. H. G. Sharpe, St. Louis, Mo.]

Serial No.	Moisture.	Proteids, N×6.25.	Ether extract.	Ash.	Crude fiber.	Carbohydrates.	Calculated calories of combustion.	Ascertained calories.	Description.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*			
15958	12.66	6.94	1.21	0.52	0.63	78.67	3,827.3	3,840	"Best."
15959	12.05	8.50	1.76	0.83	1.17	76.86	3,895.1	3,898	"Topeka."
15960	13.01	5.94	1.02	0.47	0.80	79.56	3,787.9	3,912	"Decatur."
Average.	12.57	7.13	1.33	0.61	0.87	78.36	3,836.8	3,883.3	

RELATIVE NUTRITIVE PROPERTIES OF WHEAT AND MAIZE.

There is a widespread opinion that the products of Indian corn are less digestible and less nutritious than those from wheat. This opinion, it appears, has no justification, either from the chemical composition of the two classes of bodies or from recorded digestive and nutritive experiments. A study of the analytical data of the whole grain shows that, in so far as actual nutrients are concerned, the maize is fully as nutritious as wheat. The ash content of maize and its products is probably not quite so high as that of wheat, and there is, therefore, a silght deficiency of the mineral foods employed in the nourishment of the body. Inasmuch, however, as the cereals contain an excess of mineral matters above the needs of the body, this slight deficiency is of no consequence. In respect of its content of fat, Indian corn and its products easily take precedence of all the other cereals, with the exception of hulled oats. In round numbers, it contains twice as much fat or oil as wheat, three times as much as rye, twice as much as barley, and two-thirds as much as hulled oats. In regard to digestible carbohydrates, that is, starch, sugar, dextrin, and digestible fiber, it possesses a higher content than hulled oats, almost the same as wheat, and slightly less than rye or barley. Comparing the content of nitrogenous matters with that of other cereals, it is found that the first place must be awarded to oats, especially if they have been hulled. Indian corn, however, has nearly the same quantity of proteid matter as the other leading cereals, oats excepted.

Experiments in Feeding Maize and Wheat.

In regard to the digestibility of Indian corn and wheat, it must be admitted that a larger amount of experience has accumulated with

Indian corn than with wheat. The low price of wheat in the last few years has, however, directed a considerable amount of attention to the use of that cereal instead of Indian corn in the feeding of animals. The data which have been obtained in this country, secured from comparative feeding experiments, are not always uniform. In some instances it has been found that, pound for pound, wheat gave a slightly better result in feeding animals than Indian corn, while in others the preference is given by the experimenter to Indian corn. In experiments made at the South Dakota station (Bulletin 38) pigs were fed with different cereals, among others with ground Indian corn and ground wheat. The comparative results obtained are as follows:

Summarized results of experiments with pigs.

Kind of cereal.	Weight of lot at beginning.	Average daily gain per pig.	Total grain consumed by lot.	Grain eaten per pound of gain.	Average gain.		Price realized per bushel of grain.	Shrinkage in dressing.
					Per 100 pounds of grain.	Per bushel of grain.		
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Cents.*	*Per cent.*
Lot 3, ground corn...	191	1.40	1,159	4.58	21.83	12.22	60.00	14.0
Lot 4, ground wheat.	205	1.32	1,144	4.81	20.79	12.49	58.39	16.5

In the data obtained in this experiment the Indian corn, pound for pound, was found to give the better results in every respect.

COMPARATIVE ASSIMILATION OF WHEAT AND MAIZE.

The comparative digestibility of wheat and Indian corn has been studied in the Minnesota station (Bulletin No. 36). The data obtained, with the exception of the digestibility of the ash, are as follows:

Digestion coefficients of wheat and other grains.

Constituents.	Cracked wheat.	Cracked corn.
Dry matter	82	90
Proteids	80	90
Ether extract	70	78
Crude fiber	60	48
Nitrogen-free extract	83	94

From these data it is seen that the wheat was slightly less digestible than the Indian corn. From a study of the data at the Minnesota station it may be stated that when corn and wheat are both selling at 50 cents per bushel, the 50 cents will purchase the same amount of digestible dry matter in both instances. In the case of wheat, however, the purchaser will obtain 2½ pounds more of digestible protein, and in the case of Indian corn 2½ pounds more of digestible carbohydrates. The quantity of heat generated by the food in each case is almost exactly the same. The result of these experiments, therefore, is to establish with certainty that the digestible coefficient of Indian corn is not inferior, but, if there be any difference, superior to that of wheat. Data of the kind mentioned above, based on carefully controlled feeding experiments, checked at every point by chemical analyses, are evidently of far greater value than those which are reported by the Kansas State board of agriculture for the quarter ending September 30, 1894, where circulars were sent to prominent growers of stock and reports of their observations on the comparative value of wheat and Indian corn were tabulated. As a result of the preponderance of testimony given by these circulars, it was concluded that wheat was superior to Indian corn, pound for pound, as a food for animals. These reports, however, were based merely upon observation, and were not controlled in any way by weighing or chemical analysis. The conclusion, therefore, is not valuable as evidence when contrasted with that of the feeding experiments at the Minnesota station above mentioned.

COMPARATIVE PRODUCTION OF PORK FROM WHEAT AND MAIZE.

In experiments made at the Ohio State University, collected in The Experiment Station Record, vol. 6, page 466, it was found that a bushel of wheat produced 13.7 pounds of pork, while a bushel of corn made 12.3 pounds. When the difference of weight between a bushel of wheat and a bushel of corn is considered, the actual gain, it is seen, is almost the same for both. Calculated on the market price of wheat and Indian corn, it cost $4.01 to produce 100 pounds' increase with wheat, and $2.85 to produce the same increase with Indian corn.

Carefully weighing all the reliable evidence at hand, the conclusion is inevitable that from the point of view of chemical composition, of digestibility, and of nutritive value Indian corn with its products, pound for pound, is fully equivalent to wheat. In the case of food for man, which this bulletin particularly has to consider, there must be taken into account the additional element of palatability. It is evident that in the case of two given foods of almost the same chemical composition, and of equal digestibility, the more palatable will be the more valuable food for man. In regard to palatability, as has already been mentioned, there is the widest difference of opinion. European writers on dietetics uniformly condemn Indian corn and its products as being unfit for food for man. On the other hand, the ample experience of our own country shows that it is an extremely palatable food, as well as nutritious, and a large part of our population prefer it, from a gustatory point of view, to wheat. It must be admitted, therefore, that in respect of palatability usage is an important factor, and it is evident that other nations, when accustomed to the use of Indian corn and its products as food for man, would find it equally as palatable as it is found to be in the United States.

BREAD FROM MAIZE MEAL.

Bread made from Indian corn is a popular diet in the southern part of the United States, although it is not used very extensively in the northern part nor in the western portions where Indian corn is most extensively grown. The best and most palatable breads made from Indian corn are those made from the coarsely ground meal which is simply sifted fine enough to remove the coarser parts of the bran. The meal is mixed with a little salt and water and baked into hard, unleavened cakes. In some of the more primitive methods of making this bread the dough is spread on an oak board and baked by exposure to the radiating heat of a wood fire. This kind of bread is known as johnnycake, probably a corruption of journey cake. In some parts of the North the term johnny cake is applied to a thick corn bread made of a mixture of corn meal, milk, eggs, salt, and baking powder. Indian-corn bread is sometimes leavened by a fermentation with yeast, baked in iron vessels, and is in this form known as pone. It is quite frequently leavened with baking powders, and the corn meal is sometimes mixed with wheat flour, either for domestic use or with fraudulent intent.

RATIO OF NITROGENOUS TO OTHER DIGESTIBLE CONSTITUENTS.

From a study of the composition of the typical maize, as deduced by the examination of hundreds of samples by the Division of Chemistry, it is seen that the ratio of the proteids to other digestible matters (namely, carbohydrates + fat × 2.25) is about as 10 to 80, or 1 to 8. This is a somewhat wide ratio as determined by the ordinary rules of nutrition. When it is considered, however, that if we exclude the fat, which is the most digestible of the constituents of the maize, the ratio as given above is 1 to 7, it is seen that there is practically no objection, from a nutritive point of view, to the consumption of maize as food for man or beast.

Experience is also a factor of some value in this connection. Attention has already been called to the fact that the manual labor of the southern part of the United States is done almost exclusively on a diet of Indian-corn bread and fat pork. These produce a ratio between the protein and other nutrients even larger than the one given above. And yet with this food the most severe manual labor is performed in a climate which is excessively trying to the laborer on account of its intense heat. It should also be remembered, as shown in the data given on the relative digestibility of the protein in the Indian corn and in wheat, that in many instances it has been found that protein in Indian corn has the larger percentage of digestible constituents. Further, it should be remembered that in the data above stated the ratio is given upon the whole of the constituents as determined by chemical analysis, and not upon those only which are digestible, which is the usual method for calculating the proteo-carbohydrate ratio.

Judged, therefore, by chemical composition, digestibility, and experience, it is seen that the Indian corn contains a sufficient amount of protein to make a well-balanced ration for those engaged in manual labor. It is true that a ration made of Indian corn is more fattening than one based upon oats, rye, or wheat, but in case of manual labor this tendency to the accumulation of fat is corrected, and no trouble arises in that direction.

It appears that the fat materials of Indian corn are easily digested, well assimilated, and practically consumed without waste in maintaining a high degree of muscular exertion. Even should we grant a slight deficiency in the ration of corn bread due to the low content of proteid matter, it is certain that this defect would be remedied by the development of a variety of maize richer in proteid matter. This could be easily accomplished by pursuing the system of development which was used by this division in increasing the content of sugar in sorghum. Properly conducted experimental work covering a period of ten years would result in the development of a variety of Indian corn with a higher and reasonably constant content of proteid matter. This development could be secured by taking advantage of natural and cultural conditions, combined with chemical studies of the grains, selecting for seeds those which show marked increments in the content of the proteid matter.

MAIZE OIL.

In the manufacture of starch and glucose and in some varieties of maize meal the germ of the grain, which contains the larger percentage of oil, is extracted. From this germ a valuable oil is expressed, while the residue forms a food material as valuable in every respect as that derived by the expression of the oil from ordinary oily seeds. Maize oil is easily purified and forms a light, amber-colored, perfectly transparent liquid, without rancidity and of a pleasant taste. It has been used to some extent as a salad oil, and doubtless will in the future be very greatly employed for that purpose. It can also be used for lubricating delicate machinery, has fine burning properties, and can be used as a lamp oil. The coarser and less pure oil makes a valuable soap.

In general, it may be said that maize oil has a commercial value, gallon for gallon, quite equal to the oil derived from cotton seeds.

COMPOSITION AND PROPERTIES OF THE STALKS.

Until within a few years, the stalks of maize have been considered of no value for feeding or other purposes. The blades of the stalks have been used from earliest times as cattle food, and a portion of the stalks also has been eaten by the cattle, but their true value as feeding materials has not been appreciated.

In the investigations which are given here, it was first deemed advisable to determine the relative proportion of the distinct materials in the stalk, viz, the nodes or joints, the pith, and the outer hull. The material was prepared in the following manner.

DIVISION ACCORDING TO PHYSICAL PECULIARITIES.

The stalks were received in bundles consisting of pieces about 2 feet in length and free of blades and closely adhering envelopes. Since the constituents of the stalks vary greatly in their nature, it was deemed advisable to separate them first by mechanical means into groups of approximately like nature. To accomplish this purpose, the stalks were cut in such a manner as to separate the nodes as completely as possible from the internodes. It is evident that this separation is not complete, because of the difficulty of cutting the stalk in every instance at a point which is in the line of true demarcation between the two parts. After the nodes had been removed the internodes were separated, by means of a knife, into pith and external fiber. By reason of the sharp distinction which can be made between these two parts of the internodes, this separation was accomplished in almost a quantitive way. The respective per cents of the three parts separated are given in the following table:

	Per cent.
Nodes	26.08
Pith of internodes	20.25
Shells of internodes	53.67

In round numbers it may be said that 100 pounds of Indian-corn stalks contain 26 pounds of nodes, 20 of pith cellulose, and 54 of internodular shells.

GENERAL COMPOSITION OF PORTIONS.

Each of the various portions described above was ground to a fine powder and subjected to a general analysis. The results obtained are shown in the following table:

Analysis of stalks of maize.

Constituents.	Nodes.	Pith of internodes.	Shells of internodes.
	Per cent.	*Per cent*	*Per cent.*
Moisture	6.52	7.01	4.95
Crude fiber	37.94	41.44	46.01
Ash	2.11	2.80	1.94
Fat	.94	1.17	.78
Proteids	4.38	3.50	2.44
Carbohydrates other than crude fiber	48.21	44.08	43.88

DIGESTIBILITY.

The samples were subjected to artificial digestion in order to determine the digestibility of the proteids therein. It was found that the following percentages of the protein were digestible:

	Per cent.
In the nodes	60.05
In the pith	67.70
In the shells	71.72

From the above data it is seen that, in so far as the protein is concerned, the nodes are the least and the shells the most digestible, the pith occupying an intermediate position.

SOLUBILITY WITH SEVERAL REAGENTS.

It is important in studying the properties of the stalks to determine their solubility in different reagents. Since dilute acids and alkalies are the common hydrolyzing agents, the first determination was that of the percentage of material dissolved by these bodies. The process was conducted as follows:

Ten grams of the material were digested half an hour at three atmospheres with 200 cc. of 1.25 per cent sulphuric acid. After cooling the mass was thrown on a filter and washed with water until the acid reaction disappeared. The residue was dried and weighed. The percentages given below are on the material free of water:

Solubility of different portions in acid.

Division of the stalk.	Percentage undissolved.	Percentage dissolved.
Nodes	55.72	44.28
Pith from internodes	45.73	54.27
Shells from internodes	62.31	37.69

It will be seen by the above figures that this reagent reacts most vigorously on the pith and least vigorously on the shells, the nodes occupying an intermediate position.

DIGESTION WITH ALKALI.

The digestion with alkali was carried on at ordinary pressures and in the autoclave at a pressure of three atmospheres. The time of digestion in each case was half an hour. In each instance 10 grams of the different materials were digested with 200 cc of a 1 per cent caustic soda solution. The residue on cooling was washed thoroughly with water, then with dilute acetic acid, and again with water, dried, and weighed. The solubility of the different materials in this reagent under the two conditions named was as follows:

Solubility of different portions in alkali.

Division of stalk.	Digestion without pressure.		Digestion with pressure.	
	Dissolved.	Undissolved.	Dissolved.	Undissolved.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Nodes	44.28	55.72	51.45	48.55
Pith from internodes	45.74	54.26	53:11	46.89
Shells from internodes	43.12	56.88	48.03	51.97

The action of caustic alkali at atmospheric pressure and at a boiling temperature is less efficient than heating under pressure. The latter process dissolves about half of the material and the former about 44 per cent.

The pentose sugars, that is, those containing five atoms of carbon to each molecule, are the chief products of hydrolysis, both with acid and an alkali. They are recognized by the fact that when distilled with hydrochloric acid they give rise to furfurol, which can be collected and determined, and thus the actual quantities of these sugars, as well as the bodies in the cornstalk from which they are derived, can be approximately ascertained.

FURFUROL CONTENT OF THE SAMPLES.

It is of interest to know what quantities of pentose-yielding bodies (xylan) are contained in the various samples. The furfurol determinations gave the following results:

Results for furfurol and xylan.

Division of stalk.	Furfurol.	Xylan.
	Per cent.	*Per cent.*
Nodes	13.75	22.53
Pith from internodes	12.98	21.29
Shells from internodes	12.56	20.60

SUGARS.

The sugars which are formed by digestion with acid and alkali, followed by an acid, have both the property of rotating polarized light and of reducing an alkaline copper solution. In the absence of a better method, it is customary to report the whole of the reducing sugar as dextrose. This, at best, is only an approximation; but it is the only method available until more definite knowledge is obtained respecting the properties of the mixture of sugars in the products obtained.

In the data which follow, the sugars removed by the alkali were not directly determined. The total quantity of reducing sugars in the sample, hydrolyzed by dilute sulphuric acid, was determined; in another portion, the matters removable by digestion with dilute alkali were ascertained; and in the residue the remaining sugar-producing bodies removed by digestion with dilute acid. Xylose and arabinose, which are the chief sugars produced by the above-described operations, have reducing properties that are not greatly different from those of dextrose, and therefore when expressed in terms of dextrose a near approximation to the true amount of them is secured. The following data give the copper-reducing properties of the several products:

Copper-reducing properties.

Division of stalk.	Per cent soluble in H_2SO_4.	Per cent of reducing sugars as dextrose.
Nodes	44.28	28.86
Pith from internodes	54.27	23.10
Shells from internodes	37.69	25.48

These data show that more than half of the material dissolved from the nodes and internodal fiber consists of reducing sugars, while in the case of the pith, less than half of the soluble matter belongs to that category.

After heating the various samples with an alkali, the residues, after washing with water, and acetic acid and water, were digested with dilute sulphuric acid and the reducing sugars in the products ascertained. The following results were obtained:

Results for reducing sugars.

	Nodes.	Pith from internodes.	Internodal shells.
	Per cent.	*Per cent.*	*Per cent.*
Soluble in dilute alkali	51.45	53.11	48.21
Reducing sugars in residue after hydrolysis with H_2SO_4	14.97	10.07	11.15
Reducing sugars in original sample	28.86	23.10	25.48
Reducing sugars dissolved by alkali	52.22	56.41	56.24

The difference in the nature of the bodies dissolved by acid and alkali are brought out in a striking manner by the above data. The actual quantity of material dissolved by alkali is considerably greater than is removed by an acid in the nodes and shells and only slightly less in the pith. The bodies removed by alkali, however, contain only a little more than half the quantity of reducing sugar found in the matter removed by acids. For instance, it is known that xylan is quite soluble in an alkali. It is also soluble in an acid, being converted by the latter into xylose. The alkali, however, dissolves a large quantity of material which sulphuric acid does not convert into reducing sugars. In the nodes, sulphuric acid dissolves 44.28 per cent of matter which has a reducing power equivalent to 28.86 per cent of dextrose. In the same material, caustic soda dissolves 51.45 per cent of matters which have a reducing power equal to 13.89 per cent of dextrose. It is not convenient to directly convert the alkali extract into reducing sugars by hydrolysis with sulphuric acid, because of the large quantity of sodium sulphate which would be present. The approximate amount is therefore obtained by the indirect method given above.

SUCCESSIVE DIGESTION WITH ACID AND ALKALI.

The total quantity of matter dissolved by successive treatments of the samples at 3½ atmospheres with 1.25 per cent sulphuric acid and 1 per cent caustic soda solution is shown in the following tabular statement:

Solubility in acid and alkali.

Division of stalk.	Dissolved.	Undissolved.
	Per cent.	*Per cent.*
Nodes	66.19	33.81
Pith from internodes	64.36	35.64
Shells from internodes	60.57	39.43

The soluble matter is composed of the following parts:

Composition of soluble portion.

Division of stalk.	Reducing sugars (as dextrose).	Lignose (soluble), ash, protein, fat, etc.
	Per cent.	*Per cent.*
Nodes	28.86	37.33
Pith from internodes	23.10	41.26
Shells from internodes	25.48	35.09

The composition of the samples, as determined by successive digestion with acid and alkali, and determination of the other ingredients on a water-free basis, is shown by the following table:

Division of stalk.	Ash.	Fat.	Proteids.	Insoluble carbohydrates.	Soluble carbohydrates.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Nodes	2.26	1.01	4.69	33.81	58.23
Pith from internodes	3.01	1.26	3.76	35.64	56.33
Shells from internodes	2.04	0.82	2.57	39.43	44.86

These data show that if the matters are treated with both alkali and acid in preparing them for paper pulp they will yield of that material only about one-third of their weight. On the other hand, when treated by an alkali or acid alone they will yield about one-half of their weight as paper pulp.

KINDS AND QUANTITIES OF SUGARS FORMED.

The sugars formed by hydrolysis with sulphuric acid are principally (pentose) xylose and dextrose. The relative quantities of these sugars are difficult to determine with exactness. A satisfactory approximation may, however, be secured. The quantity of dextrose formed on hydrolysis may be determined with quite a degree of accuracy by fermentation. Theoretically, dextrose should yield half its weight of alcohol. Practically, in favorable condition for fermentation about 48 per cent of alcohol may be obtained. The conditions of fermentation in the present instances were unfavorable by reason of the great dilution of the saccharine solution. We may assume, therefore, that the dextrose present yielded only 40 per cent of its weight as alcohol. The quantities of dextrose obtained by this method of calculation are given in the following table:

Results for alcohol and dextrose.

Division of stalk.	Alcohol.	Dextrose.
	Per cent	*Per cent.*
Nodes	1.36	3.40
Pith from internodes	2.16	5.40
Shells from internodes	1.92	4.80

SUGAR IN THE NODES.

In respect of pentose sugar it may be calculated on the assumption that all the pentose sugar present is xylose, or that it is a mixture of xylose with other pentose sugars. We prefer the former assumption. The quantity of pentose is therefore calculated by the formula (per cent furfurol × 1.64) ÷ 0.88.[1]

The total quantity of furfurol in the nodes was 13.75. Of this quantity 92.73 per cent was extracted by the sulphuric acid, viz, 12.75. Then 12.75 multiplied by 1.64 equals 20.91, and 20.91 divided by 0.88 equals 23.76.

Adding together the dextrose and xylose the total percentage is found to be 27.16. The total per cent of sugar dissolved was found to be 28.86.

In this instance the quantity of sugars separately determined lacks 1.70 per cent of reaching the quantity determined as a whole by alkaline copper solution.

SUGAR IN THE PITH.

The total sugars produced from the pith by hydrolysis with sulphuric acid were 23.10 per cent.

The total quantity of furfurol in the pith was 12.98 per cent, of which 94.22 per cent (equal to 12.23 of the weight of the substance) was removed by the sulphuric acid. This is equivalent to 22.77 per cent of xylose. The quantity of dextrose in the pith, ascertained by fermentation, was 5.40 per cent, which, added to the xylose calculated, gives 28.17 per cent, a quantity 5.07 per cent greater than was given by direct titration as dextrose.

SEPARATION OF CELLULOSES BY THE CHLORINATION PROCESS.

It will be observed from the foregoing data that when the materials under examination are treated successively with dilute acid and alkali under pressure, about two-thirds of the total quantity is dissolved. If, therefore, cellulose fiber were prepared by these methods, only about 33 pounds on each 100 pounds of the dry material would be secured. It is evident, therefore, that a method which would give a larger yield of cellulose from a commercial aspect would be more desirable. For this reason determination of the available cellulose is best secured by what is known as the chlorination method. This process is carried on in the following way.

About 5 grams of the finely ground material, free of water, are boiled for thirty minutes with a 1 per cent sodium hydrate solution in a vessel furnished with a reflux condenser. The undissolved portion is washed with water on a cloth filter and pressed to remove the excess of water, disintegrated, and placed in a covered beaker into which a slow stream of well-washed chlorin gas is conducted. The delivery tube conveying the chlorin gas must reach to the bottom of the beaker. The moist fiber, under the action of the chlorin, changes in color to a golden yellow as the process of absorption of chlorin gas goes on. The chlorination should last for at least an hour. The chlorinated fiber is removed, washed two or three times with water to remove excess of hydrochloric acid, and placed in a 2 per cent solution of sodium or potassium sulphite. The mixture is gradually brought to the boiling point, a small quantity of 0.2 per cent caustic soda solution added, and the boiling continued for five minutes. This separation, as a rule, is sufficient to dissolve all of the lignone bodies present, and leaves a mixture of cellulose which consists of two kinds, known as α and β. The cellulose is obtained in a pure state by washing with hot water on a cloth filter. It is also bleached by immersion in a 0.1 per cent solution of sodium hypochlorite and afterwards treated with a 0.1 per cent solution of potassium permanganate. It is thoroughly washed free of these oxidizing solutions and finally bleached with sulphurous acid on the filter, well washed with water, pressed, dried, and weighed.

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[1] Principles and Practice of Agricultural Analysis, vol. iii, p. 587.

The quantities of cellulose obtained on the dry substance by this method were as follows:

Content of cellulose.

Division of stalk.	Total cellulose.	α cellulose.
	Per cent.	*Per cent.*
Nodes	50.96	35.12
Pith of internodes	51.57	33.07
Shells of internodes	53.44	40.35

SUMMARY OF ANALYSES.

Summing up the results of the investigations, in so far as they have been made, it is seen that the material examined consists of several different kinds of matter. It contains a small quantity of mineral matter, of ash, of proteid matter, and of matter soluble in ether, but is chiefly composed of carbohydrate material. This material is of various kinds. A part of it will yield by hydrolysis with an acid a small quantity of dextrose capable of fermentation. A larger part, on hydrolysis, is converted into a pentose sugar, presumably xylose, incapable of fermentation, but capable of reducing an alkaline copper solution. Another quantity, perhaps larger than that just mentioned, passes into solution under the influence of hydrolyzing agents, but does not seem to produce a sugar capable of reducing alkaline copper solution. The largest portion of carbohydrate matter consists of cellulose of two varieties, which may be designated as α and β. Both of these celluloses are insoluble in chlorin, but the β cellulose may be dissolved in dilute nitric acid. The bodies which are capable of yielding furfurol consist largely of xylan and allied pentosan substances. There is, however, as the data have shown, a considerable quantity of matter present capable of yielding furfurol on distillation with hydrochloric acid, and yet not possessing the properties of pentosan bodies. The character and quantity of this furfurol-yielding complex is not known, and requires further investigation for its separation and study. It is evident that the material could not be profitably employed as a source of ethylic alcohol, as the quantity yielded is not quite 2 per cent in weight of the whole mass. The possibility of obtaining methyl alcohol from this matter by distillation in closed retorts is a subject for further investigation.

MAIZE STOVER AS CATTLE FEED.

The relative proportions of the different parts of maize stover have been determined by the agricultural experiment station at Geneva, N. Y., with the following results:

Proportions of stover.

Division of stalk.	Weight.		Proportion.
	Grams.	*Pounds.*	*Per cent.*
Leaves and husks	25,021	55.0	65.2
Stalks minus pith	9,046	20.7	24.5
Pith	3,948	8.7	10.3

The chemical composition of the maize stover was found to be as follows:

Chemical composition of stover.

Division of stalk.	Moisture.	Ash.	Protein.	Fiber.	Carbohydrates other than fiber.	Fat.
Air-dry materials.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Whole stover	19.81	4.55	4.19	26.02	42.87	2.56
Stover without pith	12.21	4.58	4.60	28.55	47.35	2.71
Pith	13.27	3.92	3.02	29.15	45.77	4.87
Water-free materials.						
Whole stover	....	5.68	5.22	32.45	53.46	3.19
Stover without pith	....	5.22	5.24	32.52	53.93	3.09
Pith	....	4.52	3.48	33.61	52.77	5.02

Following are the figures obtained on the analysis of a sample of thoroughly air-dried maize stover, containing the whole plant with the exception of the root and ear:

	Per cent.
Moisture	9.80
Proteids	4.31
Ether extract	2.37
Crude fiber	28.29
Ash	4.50
Cabohydrates other than crude fiber	40.33

Maize stover in some form or other is one of the most abundant foods in the United States for all kinds of farm animals. In some localities it almost excludes other forms of coarse feed, such as timothy hay, clover, etc.

PREPARATION OF MAIZE FODDER.

As has before been intimated, this fodder is often fed in the coarse state without any preparation whatever. In this condition a very large percentage of it is wasted, the cattle eating little except the blades, and perhaps some of the smaller and tenderer parts of the stalk. In the older parts of the country it is now becoming quite general to have the maize stover finely shredded before being fed. This not only increases the quantity which becomes available for feed, but also leaves the manure in a much better condition for spreading on the field.

SEPARATION OF THE PITH FROM THE FIBER.

The pith of the stalks, as will be seen further on, has valuable properties aside from its digestibility as a feed. In the separation of the pith, the outer portion of the stalk remains, and it has been found to be largely increased in value for cattle food by the separation of the pith.

Extensive experiments have been made in feeding cattle with this material, by the agricultural experiment station of Maryland and by the Geneva station of New York. The composition of the outer shell of the stalk when finely ground and subjected to analysis has been found at the Maryland station to be the following:

	Per cent.		Per cent.
Moisture	9.22	Ash	4.00
Proteids	6.38	Carbohydrates other than crude fiber	48.86
Ether extract	2.84		
Crude fiber	28.70		

Experiments were made in testing the comparative digestibility of the finely ground outer shell of the maize stalk in comparison with the coarsely shredded whole stover. The percentages of the materials digestible in these two products were found to be as follows:

Digestibility of ground and shredded stalks.

Constituents.	Ground shells.	Shredded corn fodder.
	Per cent.	*Per cent.*
Dry substance	57.6	46.8
Ash	1.9	1.3
Protein	3.8	1.6
Crude fiber	17.3	19.0
Carbohydrates other than crude fiber	32.2	23.2
Fat	2.4	1.7
Nutritive ratio	1:14.4	1:28.7

The general results of the feeding experiments made with this product show that as a feed the stover is greatly increased in value by the removal of the pith, the pith being less digestible and, on account of its high absorptive properties, consuming too much of the gastric excretions. There seems to be no doubt of the fact that the feeding value of the maize stover is very considerably increased both by the removal of the pith and by finely grinding the residual shells of the stalks.

PROPERTIES OF THE PITH.

The percentage of pith in the stalks and its chemical composition have been previously given.

The pith has a remarkably high absorptive capacity for liquids. Experiments show that it will absorb twenty-five times its weight of water.

Compressibility.—The pith is also capable of being compressed into a very much smaller bulk, but without losing its resiliency. The compressed blocks of pith still are to a certain degree flexible and are capable of absorbing immense quantities of water, but not so large as in the uncompressed state. This pith has been used with the greatest success in the construction of battle ships in the American Navy, the compressed blocks being placed between the two walls of armor and by reason of their resiliency they are found to completely close up the hole made by a projectile so as to prevent the entrance of water for a very considerable length of time. For this purpose it has been found to be immensely superior to other forms of pith which have been in use for this purpose heretofore, for instance the pith of the cocoanut.

Nitrating properties.—The pith, either directly or after extraction with a dilute alkali, is easily nitrated into all the various forms of material commonly made from cotton. It has many advantages over cotton for nitrating purposes, especially in the manufacture of explosives of all kinds, by reason of its more perfect keeping qualities. As is well known, the fibers of cotton are hollow and are filled with a mixture of acids during the process of nitration. It is found very difficult to remove these traces of acid by subsequent washing, and therefore the keeping qualities of explosives made from cotton are not of the best. The pith of Indian corn stalks is not open to the objection just urged against the fibers of cotton. It is easily nitrated, easily washed, and makes an excellent article for solution in amyl acetate or other solvent for the manufacture of varnish of different kinds and also for making substitutes for gun cotton for the purpose of manufacturing smokeless powder and other explosives.

COMPOSITION OF THE COBS.

The cobs of Indian corn have high nutritive values, but have been used in this country mostly for fuel, and not for cattle feeding. In the last few years they have been used in some localities for cattle feed after having been previously ground to a fine meal. The average composition of the whole cob, calculated from a mean of 18 analyses, is as follows:

	Per cent.		Per cent.
Moisture	10.7	Ash	1.4
Proteids	2.4	Crude fiber	30.1
Ether extract	.5	Carbohydrates not crude fiber	54.9

The cob contains a small interior core of fine pith. In the separation of the pith from the exterior substance the following proportions were found:

Percentage of pith	1.5
Percentage of shell	98.5

The pith of the corncob has many of the properties characteristic of that of the stalk, is finer in texture, however, and less absorptive. By experiment it was found that one gram of the air dry pith absorbs 10.43 grams of water. The chemical composition of the pith and the shell of the cob are found in the following table:

Chemical composition of corncob.

Constituents.	Pith.	Shell.
	Per cent.	*Per cent.*
Moisture	8.11	9.08
Ether extract	.52	.23
Fiber	34.15	32.17
Ash	2.43	1.55
Protein	2.06	1.75

Maize cobs are used to a large extent in the manufacture of pipes for smoking tobacco.

MANUFACTURE OF STARCH.

Practically all of the starch which is made in the United States is made from the grains of the Indian corn. In a few localities a small quantity of starch is made from potatoes, and in Florida and some other parts of the South still smaller quantities from the cassava. The starch of commerce, however, for the whole country is derived exclusively from Indian corn. The grains of the Indian corn contain from 60 to 65 per cent of starch, and nearly all of this is secured in commercial operations in a merchantable form. The process of starch making is extremely simple. The grains are softened in hot water until they can be easily crushed between stones or rollers into a fine pulp. This pulp is carried onto shakers lined with fine cloth, and as the pulp passes over these the starch is washed through the meshes of the cloth by a stream of water. It is customary in some localities to treat the separated starch with a dilute alkali, usually caustic soda, for the purpose of freeing it more completely from attached particles of a nitrogenous nature. The dissolved nitrogenous bodies and the alkaline waters are subsequently removed by washing with pure water. The starch is then allowed to settle, and the moist blocks are placed upon drawers and brought to the proper state of dehydration for commercial purposes. Starches intended for cooking purposes receive special treatment, and are purer and whiter than those made for laundry purposes. The quantity of Indian corn used for starch making in the United States is not actually known, but is doubtless greater than the amount used for glucose making.

MANUFACTURE OF GLUCOSE.

The manufacture of starch sugars of various degrees of hydrolyzation is an important industry in the United States. These products of the hydrolysis of starch are known as glucose or grape sugar. The glucoses represent those in which the hydrolysis is less complete, and consist largely of dextrin, dextrose, a little maltose, and water. These are made into thick and white sirups, used largely for table sirups, for adulterating molasses and honey, and for confectioners' purposes. Grape sugar is a term applied to the solid product obtained by the hydrolysis of starch in which the hydrolysis is carried to a greater extent, the resulting product consisting chiefly of dextrose. This product is chiefly used as a substitute for malt in the brewing of beer and ale. This industry has assumed immense proportions in the United States, the quantity of Indian corn annually consumed in the manufacture of glucose being about 40,000,000 bushels, or 14,095,922 hectoliters.

MANUFACTURE OF WHISKY AND ALCOHOL.

Large quantities of Indian corn are used in the United States for the manufacture of the beverage known as whisky. There is probably more Indian-corn whisky made in the United States than is made from all other grains combined. Indian-corn whisky is generally designated by the term "Bourbon," to distinguish it from the rye whisky, which is the other whisky chiefly used. The process of manufacture is entirely analagous to that used in making whisky from other cereal grains. The conversion of the starch into fermentable sugars is accomplished by diastatic action, and the resulting mash fermented and subjected to distillation. Certain volatile matters besides ethyl alcohol pass over into the distillate, especially of that group of higher alcohols known under the name of "fusel oil." The aromatic flavoring essential oils of Indian corn also appear in the distillate. After proper rectification the distilled whisky is colored with burnt sugar, placed in oak barrels, and allowed to lie in warehouses for from three to five years. During this period the fusel oils are largely oxidized to aromatic ethers, the whisky is rendered mild and agreeable in flavor, and the general improvement due to aging takes place.

Indian corn is also practically the source of all the commercial alcohols, Cologne spirits, high wines, and other alcoholic products made in the United States. The distillation of high wines, Cologne spirits. and alcohols is a great industry, consuming annually about 15,000,000 bushels, or 5,285,971 hectoliters of Indian corn.

BY-PRODUCTS IN THE MANUFACTURE OF STARCH, GLUCOSE, WHISKY, AND ALCOHOL.

The glutinous and other residues from the manufacture of starch, glucose, whisky, and alcohol are used as cattle feed. Formerly it was the custom to employ these waste matters in the moist state, but in most parts of the country this method has been superseded by the method of drying the residues and selling them in the practically anhydrous condition. In this state they are much more easily transported, the objectionable odors which were a predominant characteristic of the moist foods are removed, and the wholesomeness of the food is in every way promoted. The method of preparing these foods is practically the same as that used in the saving of residues from breweries for feeding purposes, and the nutritive value of the Indian-corn residues is quite equal to that of brewers' grains.

CONCLUSION.

An attempt has thus been made to briefly review the chief points connected with the constitution and economic value of the Indian-corn plant. It is predominantly the characteristic cereal crop of the United States, and its money value is, perhaps, greater than that of any one crop, with the exception of cotton. It has been shown that it is a valuable food for man and that it is the chief food of the domestic animals of our great country. In addition to this, large quantities of starch are made from it, and also glucose and grape sugar. It not only serves as our food, but also furnishes a part of our drink, in the form of the various grades of Indian-corn whisky. In addition to this, it is the source of an immense industry in the manufacture of alcohols, high wines, and Cologne spirits. The stalks, which a few years ago were considered an injurious residue, have been found to possess most valuable properties as cattle food. Especially is this true of the outer shells. The inner portion of the stalk—the pith—possesses remarkable properties as an obturator in the manufacture of battle ships. It possesses a high degree of resilience and porosity, and when perforated by a shot or shell it instantly closes the aperture made by the projectile, and thus prevents the entrance of water into the vessel. It also has peculiar properties rendering it suitable for the manufacture of pyroxylin varnishes, gun cotton, and high explosives. By reason of the nature of its construction it is easily nitrated. The acids are completely removed by washing, and the resulting compound is more stable, and therefore more valuable, than that which is derived from cotton under similar treatment.

It has been deemed wise to collect the above results of recent work which has been done in the Chemical Division of the Department of Agriculture on the subject of Indian corn, especially because the merits of this plant are not well appreciated in Europe, where Indian corn is not regarded as a fit source of human food, and where its genuine nutritive properties and the properties of the stalks are not known. It is believed that by calling the attention of the scientific men of Europe to Indian corn, good will result, not only to the country which is interested in the growth of this great cereal, but to Europe, where cheap and nutritious food products are desired.

BULLETIN NO. 51.

U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF CHEMISTRY.

PROCEEDINGS

OF THE

FOURTEENTH ANNUAL CONVENTION

OF THE

ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS

HELD AT

WASHINGTON, D. C.,

OCTOBER 26, 27, AND 28, 1897.

EDITED BY

HARVEY W. WILEY,
SECRETARY OF THE ASSOCIATION.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1898.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF CHEMISTRY,
Washington, D. C., January 17, 1898.

SIR: I beg to transmit herewith, for your inspection and approval, the manuscript of the proceedings of the fourteenth annual meeting of the Association of Official Agricultural Chemists, and ask that it be printed as Bulletin No. 51 of the Division of Chemistry.

H. W. WILEY,
Chief of the Division of Chemistry and Secretary of the
Association of Official Agricultural Chemists.

HON. JAMES WILSON,
Secretary of Agriculture.

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PROCEEDINGS OF THE FOURTEENTH ANNUAL CONVENTION OF THE ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS.

FIRST DAY.

TUESDAY—MORNING SESSION.

The fourteenth annual convention of the Association of Official Agricultural Chemists was held in the lecture hall of the Columbian University, beginning October 26, 1897. The meeting was called to order by the president, Mr. William Frear, who appointed Messrs. Patterson, Davidson, and Hills a committee on order of business. The committee reported as follows:

First. Report on nitrogen.
Second. Report on potash.
Third. Report on phosphoric acid.
Fourth. Report on soils and ash.
Fifth. Report on foods and feed stuffs.
Sixth. Report on food adulteration.
Seventh. Report on dairy products.
Eighth. Report on sugars.
Ninth. Report on fermented and distilled liquors.
Tenth. Report on tannin.

The election of officers was made a special order for Wednesday, October 27, at 3 p. m.

Upon motion the report was adopted.

The president read the following annual address to the association.

ADDRESS OF THE PRESIDENT.

MEMBERS OF THE ASSOCIATION OF OFFICIAL CHEMISTS: It is customary, at the opening of each annual convention of the association, for your presiding officer to make a few introductory remarks relative to its aims and work. It is well for the ship if the officers and the lookouts be not satisfied with the progress indicated by the beating throb of the engine, but are also keenly observant of her course and her speed, keeping a watchful eye upon compass and log.

It is likewise well for such an association as ours if those concerned in its work are not content simply with the performance of much routine work along lines already well fixed by the earlier work of the association, but study also the logic of its progress and growth, the new demands each step in the science of the chemist, the art of the technologist, and the statute of the legislator makes upon it.

The early inception of the idea of this organization was due to the friction between buyer and seller and their arbitrators, the chemists, resulting from differences in the methods of determining the phosphoric acid in that ill-defined group of materials called "reverted phosphates". The purpose of the association was, by study of details of method, to arrive at uniformity of analytical processes; and, by comparison of results of manipulation in the laboratories concerned, to arrive at identity of analytical results by different chemists upon the same material.

The striking benefits that followed these efforts induced those interested in the work of the agricultural experiment stations, organized not long after, to attempt a similar unification of methods for the determination of the ill-defined groups of substances whose separation is attempted in the course of investigations upon animal nutrition. Work upon soil and ash analysis, upon dairy products, and upon other products of rural industry, such as sugar products, wines, etc., was undertaken soon after.

Finally, the growing recognition of the value of chemical analysis in the control of tanning operations has led to the formation of a group of workers upon the methods applicable to the analysis of tanners' raw materials and their products.

Primarily, the work of the association has been chiefly along the lines of importance to the official chemist. This must still be, to a large extent, true of the association's work. But it will fail of its high opportunities and choose an ideal lower than it may properly select if its work be not pushed also, in a large measure, along more distinctly scientific lines.

The work in determination of available plant food in soils, the study of the methods of analysis applicable to slag phosphates, the test of various methods for the separation and determination of simple substances and narrower, better-defined groups of substances in cattle foods and dairy products, the studies of solubilities of various phosphates, may be cited as illustrations of valuable work by the association in this field. If we would accomplish most, we must remember that the ideal accomplishment is not the perfection of an arbitrary method for the determination of an ill-defined group of substances, but, much further on, the attainment of a method by which such a group may be resolved into its simple components, and the effective value of each determined. For example, the work upon phosphoric acid will not be finished by the shaping of a method capable of yielding excellent duplicate results upon dissolved phosphate, raw phosphates—calcic and ferruginous—upon bones and slag alike; but only when, by the methods devised (probably a separate method for each), it is made possible to gain an idea of the available plant food that each will yield under some normal condition, or, it may be, under several distinct classes of conditions. This is, indeed, a far more difficult field of operation, but it is none the less important.

It may be well, at this point, to refer to an impression prevailing in the minds of some of our associates. As an incident to the perfection of fertilizer methods there came the opportunity of comparison of the results of manipulation by different analysts. A valuable training was thus afforded to the young beginners with whom our laboratories, sprung suddenly into existence, were largely manned. The opportunity thus afforded is extremely valuable in its influence both upon the accuracy of the analyst and upon the confidence of the man whose goods he values. Some, indeed, came to regard this as the chief *raison d'être* of the association, and have suggested the desirability of so conducting its work that it shall become practically a "moot court" for tyros in analysis. Without depreciating at all the value of such comparison, I protest earnestly against such a conception of the work to be done. There is ample scope for the exercise of generalship on the part of our more experienced members, as well as for drill to the juniors of our organization.

With these brief comments upon the general work of the association, I desire to again call your attention to the fact that the prime work of the association is along lines important to the official agricultural chemist. At first his work was confined almost exclusively, in America, to the fertilizer control. The association's transactions in this domain have been of great helpfulness to those concerned in the analysis of fertilizers, whether as manufacturers, as sellers, as buyers, or as control officials.

But parallel with the fertilizer control work, there has arisen a demand upon the agricultural chemist for the application of analytical methods to the detection of food adulterations, with a view to insuring their prevention. For the chemist engaged in this work the association has done little that is directly and specifically useful—this is said with full remembrance of our work on milk and its products, sugar products, and alcoholic liquors. Our effort has been chiefly directed toward the perfection of methods devised to determine the normal constituents of certain food materials, scarcely at all to the detection and estimation of foreign admixtures. The former work should be continued, but there is a pressing demand for the latter. I wish particularly to note a few facts and to offer a few suggestions with reference to this latter work.

It may not be amiss to consider the great values concerned. Waldron (Handbook of Currency and Wealth, 1896, p. 101) estimates the nation's expenditure for food to be $3,305,000,000, and for liquors $900,000,000, making a grand total of $4,205,000,000, or nearly 31 per cent of the entire expenditure for necessaries, luxuries, and capital; and this grand total does not include those articles of food properly classed as luxuries.

Edge (Rept. Pa. Dept. of Agriculture, 1895, p. 215) estimates the value of the food consumed in the country at $4,500,000,000; and Commissioner McNeal, of Ohio, that of foods, drinks, and drugs at $7,280,000,000.

From the records prepared under the direction of Hon. Carroll D. Wright, United States Commissioner of Labor (Sixth and Seventh Annual Reports), showing the earnings and itemized expenditures of 6,809 families, containing 35,312 persons, representing the iron and steel workers, bituminous coal miners, ore miners, limestone quarrymen, glass workers, and cotton and wool workers of the country, I find that the average family spent upon its food 39.4 per cent of its total income—a proportion much larger than that given by Waldron, who fixed the average at 24.23 per cent. These figures from Wright's records do not include expenditures for alcoholic liquors. If applied to the whole population, they would bring the total to $3,244,000,000; of this amount 52 per cent, or $1,687,000,000, was spent upon adulterable foods.

The following statement of the values of the food products manufactured in the United States in 1889 I have summarized from the figures of the Eleventh Census:

Flour, milling and bakery products (less the materials used in bakeries)	$569, 885, 430
Fruit, vegetables, food preparations, pickles (including canned oysters)	63, 991, 790
Sugars, sirups (refining), glucose, and confections (less materials used by confectioners)	155, 755, 417
Dairy products, lard, and oleo	71, 149, 146
Condiments, flavoring extracts, salt, and vinegar (including cider)	22, 155, 238
Table beverages and bottled drinks (including spices)	92, 847, 103
Alcoholic liquors	289, 775, 639
Total	1, 265, 559, 763

But this category omits many highly important food products—not only such as undergo no manufacturing process before they come to the kitchen and are little liable to adulteration, such as fresh meats, eggs, fruits, vegetables, and nuts—but also canned and pickled meats and fish, honey, crude sirups and sugars, and milk. Neither does it include those materials ready for family use.

The census figures show the following amounts for certain of these products in 1890:

Products.		Amount.	Price.	Total.
			Cents.	
Honey	pounds	63, 897, 327	5	$3, 194, 866. 35
Cane molasses	gallons	25, 409, 228	30	7, 622, 768. 40
Sorghum molasses	do	24, 235, 219	28	6, 785, 861. 32
Maple sirup	do	2, 258, 376	60	1, 355, 025. 60
Maple sugar	pounds	32, 952, 927	8	2, 636, 234. 16
Roughly valued at				21, 594, 755. 83

The Eleventh Census makes the total value of the homemade and factory-made dairy products and of the milk not transformed into manufactured products $411,976,522. Alvord (Bulletin No. 11, Bureau of Animal Industry) makes a higher estimate, $454,900,000, which, in view of the fact that the census figure includes statements from only such factories as made returns, and many failed to make the proper returns, is probably not too high. Alvord includes the yield of town cows, omitted by the census.

Much, however, of this dairy product never leaves the farm. How much is sold it is difficult to estimate. From my own observation I incline to believe that the per capita consumption of whole milk, butter, and cheese is less on the farm than elsewhere.

In 1890 the per capita production of butter, according to the census, was 19 pounds, deducting the amount exported; 21.7 pounds according to Alvord's estimates; of cheese, according to the census, 3.7 pounds; according to Alvord, 4.1 pounds. Alvord also estimates the average direct milk consumption at 25½ gallons of whole milk per capita.

In 1890 Boston had a population of 488,477; it has probably grown somewhat since then. Correspondence with Hon. George M. Whitaker, executive officer of the Massachusetts dairy bureau, places the annual milk delivery in Boston at about 31,800,000 gallons; and of butter—based upon five months' returns, less corresponding exports—at 54,067,200 pounds. Estimating that the market supplies 600,000 population with butter and 500,000 with milk, this makes the annual consumption per capita 90 pounds of butter and 60½ gallons of milk. The amount of both butter and milk made up into other food preparations and exported in such guise I have not been able to estimate.

In 1890, New York had a population of 1,515,301. The New York dairy and food commissioner states the annual consumption of that city to be:

Butter	pounds..	85,880,442
Cheese	do....	38,224,752
Condensed milk, cream, and whole milk, equivalent to the whole milk (*circa*)	gallons..	107,410,000

Equivalent per capita, assuming a present population of 1,750,000, to—

Butter	pounds..	49.1
Cheese	do....	21.8
Milk	gallons..	61.4

These per capita figures, while doubtless excessive,[1] indicate, nevertheless, that the rate of consumption of these dairy products on the

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[1] In a recent letter Mr. Whitaker says: "The city of Boston proper is surrounded by a circle of towns and cities. The business interests of these places are united with the business interests of Boston, and they are collectively called 'Greater Boston.'

"The milk of Greater Boston comes, first, by rail from a territory roughly stated as between 25 and 150 miles distant from Boston; second, by wagon from a territory farm must be far less than the most urban communities. So that an assignment of one-fourth of these dairy products to the rural communities, a proportion equal to that their working population bears to the entire working population of the country, leaves a balance for dairy products sold upon the market and liable to adulteration that is certainly too low. This balance, after deducting the nearly $63,000,000 worth of dairy products made in the factories, is about $350,000,000 worth.

For pickled and canned meats I have obtained no satisfactory figures.

So many of our imports of food materials have already been accounted for as raw materials, that I will not consume your time by any elaborate showing of their importance, but will simply note the following items for the year ending June 30, 1896:

Bottled drinks, nonalcoholic	$288,963
Macaroni	599,836
Infants' foods	66,545
Lemon juice, etc	84,073
Vanilla bean	1,013,609
Chocolate, chicory, cocoa, and coffee, with substitutes	88,151,593
Farinaceous substances	257,588
Anchovies	956,255
Malt liquors	1,652,971
Vegetable oils	2,688,051
Extract of beef	214,932
Rice flour	916,512
Saccharin	53,760
Salt	752,108
Spices	2,137,197
Mustard	227,928
Distilled spirits	2,098,122
Sugar, molasses, and confectionery	84,369,504
Tea	12,688,740
Vegetables, canned and pickled	1,045,999
Waters, soda, etc	585,694
Wines	7,212,997

When it is further shown, as the records of our various State food controls amply proye, that from 5 to 15 per cent of the entire food

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within 25 miles of the city; and third, a small amount is produced in this territory, for as we go out of Boston some of the towns shade off to agricultural communities and keep quite a number of cows. The figures which I gave you refer to the milk supply of Greater Boston.

"Second, as to your inquiry about butter: The expression 'butter exported' means butter exported across the water, particularly to England. The Chamber of Commerce receives from the railroads the amount of butter brought to the city. From this the butter exported is deducted, and the balance is called 'domestic consumption.' This is butter which goes into the ordinary lines of trade from Boston as a commercial center, but is almost entirely consumed in eastern Massachusetts, southern New Hampshire, and a little in Rhode Island. Occasionally a drummer finds his way into the western part of the State, but that is an agricultural community and very largely supports itself. The same is true for eastern Connecticut. Western Connecticut is principally supplied from the New York market, and New York firms compete with Boston firms for the business of Rhode Island."

supply upon the markets is adulterated, and that fully 10 per cent of the adulteration is injurious to health, little further is needed, it seems to me, to emphasize the importance of the work of the food control and of all subjects relating thereto.

There are two ways in which this association can aid the food-control chemist:

(1) By the careful selection, accurate description, and test of methods fitted for the control examination of the various classes of adulterable food materials upon the market. Food-control chemists differ to-day in their results even more than fertilizer-control chemists differed when this association was organized, and both from the same cause, namely, the use of different methods for the same determination. The prevalence of these differences among reputed experts seriously impairs the confidence of judicial and administrative officers in the chemist's work and begets a justifiable timidity on the part of the honest manufacturer and dealer, whose hearty cooperation is most important to the success of the control. All concerned in this work have much to hope for from the unification and improvement of analytical methods in this field of operation. Toward this end the association looked in the appointment last year, for the first time, of a reporter on food adulteration.

(2) By taking steps to secure the establishment of standards of composition for pure food substances, just as the druggists have done for drugs. The United States Pharmacopœia is the accepted authority as to standards for the purity of drugs, and incidentally for a few food substances. Most State and municipal laws relating to the control of drug adulteration distinctly accept the pharmacopœial standards of purity. A similar work must be done for foods. In the absence of such an accepted set of standards each food chemist is compelled to formulate his own. The result is that the standards used by different chemists are based upon insufficient data and are formulated according to different canons, with the consequence that legal actions are instituted in good faith by control officers only to be lost by the failure of the several experts to agree upon the essential bases of comparison.

Another result of this lack of consensus of expert opinion, based upon the most reliably ascertained facts of food composition, is the incorporation into legislation of arbitrary standards that work serious injustice to innocent producers and dealers.

I earnestly hope that this year this association may, from its vantage point of successful attainment in other directions, begin a movement to overcome these difficulties under which the official food analyst to-day labors.

MEMBERS AND VISITORS PRESENT.

The following members and visitors were present:

Allen, E. W., Office of Experiment Stations, United States Department of Agriculture, Washington, D. C.
Anderson, James T., Alabama Experiment Station, Auburn, Ala.
Atwater, B. M., Syracuse, N. Y.

Bartlett, J. M., Agricultural Experiment Station, Orono, Me.
Beal, W. H., United States Department of Agriculture, Washington, D. C.
Bigelow, W. D., Division of Chemistry, United States Department of Agriculture, Washington, D. C.
Bryant, A. P., Storrs Experiment Station, Middletown, Conn.
Carpenter, F. B., Virginia-Carolina Chemical Company, Richmond, Va.
Carr, Oma, Corry, Pa.
Chesnut, V. K., Department of Agriculture, Washington, D. C.
Clark, Reed Paige, Washington, D. C.
Coates, Charles B., jr., Louisiana State University, Baton Rouge, La.
Craighill, G. P., Lynchburg, Va.
Crampton, C. A., Treasury Department, Washington, D. C.
Cutter, W. P., United States Department of Agriculture, Washington, D. C.
Davidson, R. J., Experiment Station, Blacksburg, Va.
Dickeson, William E., United States Appraiser's Office, Philadelphia, Pa.
Ellett, W. B., Experiment Station, Blacksburg, Va.
Ewell, E. E., Department of Agriculture, Washington, D. C.
Fernandez-Cavada, Fernando, Audubon Park, New Orleans, La.
Frear, William, Experiment Station, State College, Pa.
Fulmer, Elton, Experiment Station, Pullman, Wash.
Gaines, Richard H., Department of Agriculture, Richmond, Va.
Hand, W. F., Agricultural College, Miss.
Haywood, J. K., United States Department of Agriculture, Washington, D. C.
Hills, Joseph L., Experiment Station, Burlington, Vt.
Hird, J. D., Washington, D. C.
Hite, B. H., Experiment Station, Morgantown, W. Va.
Huston, H. A., Experiment Station, Lafayette, Ind.
Jenter, C. G., Experiment Station, Geneva, N. Y.
Jones, Charles H., Experiment Station, Burlington, Vt.
Kilgore, B. W., Agricultural College, Miss.
Knox, Roy, Morgantown, W. Va.
Krug, William H., United States Department of Agriculture, Washington, D. C.
Krumbhaar, Charles Conrad, Audubon Park, New Orleans, La.
Langworthy, C. F., United States Department of Agriculture, Washington, D. C.
Laughlin, J. R., Maryland Agricultural College, College Park, Md.
Lehmann, G. W., Chemist, Board of Health, Baltimore, Md.
Lindsey, J. B., Hatch Experiment Station, Amherst, Mass.
McDonnell, H. B., Maryland Agricultural College, College Park, Md.
Moore, C. C., United States Department of Agriculture, Washington, D. C.
Munroe, C. E., Columbian University, Washington, D. C.
North, J., 205 Third avenue, New York City, N. Y.
Patrick, George E., United States Department of Agriculture, Washington, D. C.
Patterson, H. J., Experiment Station, College Park, Md.
Peacock, S., Philadelphia, Pa.
Penny, C. L., Experiment Station, Newark, Del.
Perkins, George E., 72 Jackson street, Providence, R. I.
Persons, A. A., Experiment Station, Lake City, Fla.
Ross, B. B., Auburn, Ala.
Runyan, E. G., United States Department of Agriculture, Washington, D. C.
Schweinitz, de, E. A., Department of Agriculture, Washington, D. C.
Scovell, M. A., Experiment Station, Lexington, Ky.
Skinner, W., Maryland Agricultural College, College Park, Md.
Spencer, G. L., United States Department of Agriculture, Washington, D. C.
Street, John Phillips, Experiment Station, New Brunswick, N. J.
Sweetser, W. S., Experiment Station, State College, Pa.

Thigpen, J. H., Washington, D. C.
Trescot, T. C., United States Department of Agriculture, Washington, D. C.
Van Slyke, L. L., Experiment Station, Geneva, N. Y.
Veitch, F. P., Maryland Agricultural College, College Park, Md.
Wainwright, J. H., United States Appraiser's Office, New York City, N. Y.
Welty, Harry T., College Park, Md.
Wheeler, Edward J., Department of Agriculture, Albany, N. Y.
Wheeler, H. J., Experiment Station, Kingston, R. I.
Wiley, H. W., United States Department of Agriculture, Washington, D. C.
Williams, C. B., Experiment Station, Raleigh, N. C.
Winton, A. L., Experiment Station, New Haven, Conn.
Withers, W. A., Experiment Station, Raleigh, N. C.
Yocum, J. H., United States Leather Company, New York City, N. Y.

The PRESIDENT. It is customary at this time to appoint a committee to acquaint the honorable Secretary and Assistant Secretary of Agriculture with the fact that we are in session and request their presence at such time as they may find it possible to come. If there be no objection, the Chair will now appoint as such committee the vice-president of the association, Mr. Winton, and Mr. Kilgore, of Mississippi.

Upon Mr. Wiley's suggestion, the committee was directed to invite the Secretary (the Assistant Secretary being out of town) to be present on Wednesday morning at 11 o'clock, at which hour probably a larger number of members would be present.

Mr. Street, of the New Jersey station, then read the report on nitrogen, as follows:

REPORT ON NITROGEN.

By JOHN PHILLIPS STREET, *Referee.*

The work for the year will be considered under three heads.

I. The determination of nitric nitrogen.
II. The determination of total nitrogen.
III. The determination of the availability of organic nitrogen.

Early in January a letter requesting cooperation was addressed to fifty-five chemists, representing all of the American experiment stations and several commercial firms. Twenty-five favorable replies were received to this letter, fifteen chemists agreeing to do the regular work and ten the work on organic nitrogen. Of this number, eight have reported results on nitric and total nitrogen and seven on organic nitrogen. On February 8 a letter of instruction was sent to those who had signified a wish to take part in the work.

PREPARATION OF SAMPLES.

Three samples of fertilizers were prepared for distribution. The materials used in compounding these mixtures were nitrate of soda, cotton-seed meal, acid phosphate, potassium chlorid, and Lobos guano. The sample of nitrate of soda was prepared by recrystallizing a quantity of commercial nitrate twice, with a final evaporation to dryness. No attempt was made to secure an absolutely pure product, and traces of chlorids, sulphates, and moisture were shown to be present by subsequent tests. The Lobos guano was a complete fertilizer, the source of whose nitrogen was a natural guano. It was thought by the referee that the use of such a material would be as severe a test of the methods as could be desired.

These ingredients were dried for five hours at from 60° to 70° C., and then were allowed to stand exposed to the air for fifteen hours, in order that they might become in equilibrium with the atmosphere. They were then ground to pass through a one twenty-fifth inch sieve, except the nitrate of soda and potassium chlorid, which were passed through a one fiftieth-inch sieve. The samples were then thoroughly mixed and portions selected for analysis, the results of which follow:

Composition of samples.

Substance.	Nitric nitrogen.	Ammonia.	Organic nitrogen.	Total nitrogen.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Nitrate of soda	16.25	16.25	....	16.25
Cotton-seed meal	....	....	6.93	6.93
Lobos guano	.33	1.99	.94	3.26

No traces of nitrogen were found in the acid phosphate or potassium chlorid.

The ingredients of the different mixtures were then spread out on a heavy paper and thoroughly mixed by turning with a spatula. They were then bottled and securely sealed.

The mixtures were made up as follows:

Sample 1:
    1,000 grams nitrate of soda, containing 162.50 grams nitrogen,
        Or 16.25 per cent nitric nitrogen.
Sample 2:
    100 grams nitrate of soda, containing 16.25 grams nitrogen;
    300 grams cotton-seed meal, containing 20.80 grams nitrogen;
    500 grams acid phosphate;
    100 grams potassium chlorid,
        Or 3.71 per cent total nitrogen, containing 1.63 per cent nitric nitrogen.
Sample 3:
    100 grams nitrate of soda, containing 16.25 grams nitrogen;
    900 grams Lobos guano, containing 29.34 grams nitrogen,
        Or 4.56 per cent total nitrogen, containing 1.66 per cent nitric nitrogen and 1.79 per cent as ammonia.

I.—THE DETERMINATION OF NITRIC NITROGEN.

The work on nitric nitrogen consisted in a test of the Ulsch-Street method in comparison with the Scultze-Tiemann method. It was the expressed sentiment of the last convention that the Ulsch-Street method should be given a fair and general trial this year. In light of this fact, it was hoped that a large number of analysts would test it in their work. The chemists who objected so strongly to the adoption of this method last year have shown their deep interest in its success this year by refraining, with hardly an exception, from using it in a single test.

The modified Ulsch method recommended was the same as that given in Bulletin 49, United States Department of Agriculture (p. 13), except that from 7 to 10 grams of heavy oxid of magnesia free from carbonates were suggested instead of the smaller quantity previously used. The Schulze-Tiemann method used was that given by Fresenius in his Quantitative Analysis (Amer. Ed., 1886, pp. 473–475).

Comparison of methods.

Analysts.	Nitrate of soda.								
	No. 1.					No. 2.		No. 3.	
	Ulsch-Street.	Schulze-Tiemann.	Kjeldahl.	Gunning.	Absolute.	Ulsch-Street.	Schulze-Tiemann.	Ulsch-Street.[1]	Schulze-Tiemann.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
T. C. Trescot, U. S. Dept. of Agr.	16.23	16.22	......	......	16.26	1.64	1.60	1.77	1.72
H. K. Miller, N. C. Station	16.30	16.28	......	......	......	1.69	......	1.74	......
C. H. Jones, Vt. Station	[2]15.99	......	......	......	......	1.61	......	1.76	......
F. B. Bomberger, Md. Station	16.14	......	......	16.10	......	1.63	1.64	1.68	1.69
R. J. Davidson, Va. Station	16.13	......	......	......	......	1.70	......	1.72	......
C. S. Cathcart, Lister's Agricultural Chemical Works	16.12	......	......	......	......	1.70	......	1.61	......
A. M. Peter, Ky. Station	[2]15.70	......	......	......	......	1.71	......	1.68	......
H. E. Curtis, Ky. Station	[2]15.66	......	16.25	16.14	......	1.70	......	[2]1.51	......
J. P. Street, N. J. Station	16.24	16.32	......	......	......	1.71	1.62	1.73	1.66
A. W. Ogden, Conn. Station	16.20	......	......	......	......	1.70	1.52	1.77	1.62
Average	16.19	16.27	16.25	16.12	16.26	1.68	1.60	1.72	1.67
Theory	16.25	......	......	......	......	1.63	......	1.66	......

[1] 1.86 per cent ammonia deducted.

[2] Omitted from the averages.

COMMENTS OF ANALYSTS.

T. C. Trescot.—The results obtained on sample 1 by the Ulsch-Street method were very unsatisfactory. The result reported is the average of the three highest (16.21, 16.22, and 16.28) of many determinations.

H. K. Miller.—In working on sample 1 by the Ulsch-Street method I found it necessary to use dropping bulbs to prevent loss. I was unable to get satisfactory results with the Schulze-Tiemann method, as I was unable to get apparatus perfectly tight; and in working with samples 2 and 3 by this method frothing was so bad that I had to give up making determinations on these two samples. I used caustic soda, also, in determining nitric nitrogen by the Ulsch-Street method in Nos. 2 and 3 and obtained higher results, though I send you only the results obtained from using magnesium oxid.

A. M. Peter.—Instead of using the small amount of water, as per your instructions, and distilling nearly to dryness, I used 300 cc of water, and in the case of Nos. 2 and 3 mixed the magnesium oxid with part of this water to a cream, for the sake of more thorough action, and distilled off about 220 or 230 cc. By subsequently carrying the distillation nearly to dryness, it was found that in each case practically all the ammonia had been obtained in the first distillate. The largest amount obtained in the second distillation was only 0.07 per cent in No. 2, the others being mere traces or none at all. My idea is that if from 300 to 350 cc of water be used and the precaution taken to mix the magnesium oxid with part of the waters so that it will not form lumps and interfere with the action, there will be no difficulty in obtaining all the ammonia by distilling off not less than two-thirds of the total volume of the liquid.

A. W. Ogden.—We found the Ulsch-Street method as applied to nitrate salts very satisfactory indeed. We will probably use it next year in the analysis of our nitrate of soda samples. The Ulsch-Street method gave very good results on mixed fertilizers, although it is not certain that it will prove in our hands, all things considered, superior to our old standby, the Schulze-Tiemann.

Ten chemists reported results by the modified Ulsch method. The results this year on the nitrate of soda sample are a decided improvement on those of past years. Seven of the ten analysts secure results within 0.13 per cent, while four are within 0.05 per cent of theory. One of the others is 0.26 per cent low, while the other two, representing the work of two chemists at the same station, are from 0.55 to 0.59 per cent low. Eliminating these two results, which were obtained by a method not strictly in accord with that sent out, the difference between the lowest result of the others and theory represents a variation of but 0.016 per cent of the total nitrogen in the sample. Had these results been secured on a 4 per cent sample this variation would represent a difference of but 0.06 per cent.

The results secured on samples 2 and 3 are also excellent, the extreme range between highest and lowest being 0.10 per cent in No. 2, and omitting one result, 0.16 per cent in No. 3. The greatest variation from theory in No. 2 is 0.08 per cent and in No. 3, with one exception, 0.10 per cent. Attention is called to the fact that the low result on No. 3 is reported by the same chemist who reported a low result on No. 1. This would seem to indicate that the method was not altogether responsible for the discrepancies.

The comparison of results by the Ulsch-Street and the Schulze-Tiemann methods, while representing the work of but four chemists, is very satisfactory, the average difference being 0.08 per cent in No. 1, 0.08 per cent in No. 2, and 0.05 per cent in No. 3. It would seem that a fairer comparison of these two methods would be secured by using the results of only those chemists who tried both methods. On this basis we have—

Ulsch-Street.			Schulze-Tiemann.		
No. 1.	No. 2.	No. 3.	No. 1.	No. 2.	No. 3.
Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
16.23	1.64	1.77	16.22	1.60	1.72
16.30	1.63	1.68	16.28	1.64	1.69
16.24	1.71	1.77	16.32	1.52	1.62
[1]16.26	[1]1.67	[1]1.74	[1]16.27	[1]1.60	[1]1.67

[1] Average.

These results are excellent, and show that the Ulsch-Street method, instead of giving low results as has been claimed, has, on the other hand, a tendency to give slightly higher results, the differences being 0.07 per cent in favor of the Ulsch method in both samples 2 and 3. This is quite in accord with the well-known fact that the Schulze-Tiemann gives low results unless the utmost care is exercised in its manipulation.

In a comparison of these methods on samples of commercial nitrate of soda, the referee secured the following results: In a total of thirteen samples the Ulsch method gave higher results in nine samples and lower in four. The greatest variation was 0.11 per cent; the averages were 15.87 per cent, being identical by the two methods.

The results secured by the Ulsch-Street method this year confirm the referee's belief in its accuracy, its efficiency, and its adaptability to the work of this association. That the method requires care in its manipulation is not peculiar to this method alone, and should be no objection to its use. Aside from its accuracy, its rapidity is one of its strongest recommendations. This advantage may not appeal strongly to many of the chemists who have little work to do along this line, but to those stations where several hundred nitrate determinations are required each year, as in the New Jersey Station, a rapid method is essential. As has been pointed out before, nearly one-half the time can be saved by using this method.

II.—THE DETERMINATION OF TOTAL NITROGEN.

At the last meeting of this association the referee was requested to ascertain whether the method called the Fassbänder method was not erroneously named. In obedience to this request, the referee wrote to Dr. Fassbänder, who first called it to the attention of this association, and received the following reply:

KEMPEN AM RHEIN, *April 21, 1897.*

Mr. JOHN P. STREET, *New Brunswick, N. J.*

DEAR SIR: The method which I employed in 1894 in the determination of nitrogen in the presence of nitrates was not first suggested by me, but by Dr. V. Schencke in No. 54 of the Chemiker Zeitung for 1893. It is known here as the Ulsch-Kjeldahl method, and is rapidly coming into general use.

Respectfully, yours,
DR. FASSBÄNDER.

The work on total nitrogen this year consisted of an examination of the Ulsch-Kjeldahl and Ulsch-Gunning methods in comparison with those already in use. The Ulsch-Kjeldahl and Ulsch-Gunning methods are simply a combination of the Ulsch method with the Kjeldahl and Gunning methods, respectively. The former is the method suggested by Dr. Schencke; the latter was suggested to the referee by Mr. A. L. Winton, of the Connecticut Station, in private correspondence. The methods as outlined by the referee in his letter of instructions are as follows:

ULSCH-KJELDAHL METHOD.

Weigh 1 gram of material into a Kjeldahl flask, cover with 20 cc of water, shake and allow to stand for ten minutes. Then add two grams of powdered iron (reduced iron answers very well) and 10 cc of sulphuric acid (sp. gr. 1.35). Warm gently on furnace until evolution of hydrogen ceases. Add 0.7 gram of mercuric oxid and 20 cc of strong sulphuric acid, and then proceed as in the regular Kjeldahl method.

ULSCH-GUNNING METHOD.

Make the preliminary conversion as above with reduced iron and dilute sulphuric acid. Proceed as in the regular Gunning method as given in Bulletin 46, United States Department of Agriculture, page 17. In samples rich in carbon, as sample No. 2, it is necessary to boil for some time after the liquid becomes colorless.

Comparison of methods.

Analysts.	No. 2.				No. 3.			
	Kjeldahl.	Ulsch-Kjeldahl.	Gunning.	Ulsch-Gunning.	Kjeldahl.	Ulsch-Kjeldahl.	Gunning.	Ulsch-Gunning.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
T. C. Trescot, U. S. Dept. of Agr.	3.73	....	3.75	3.70	4.51	....	4.54	4.52
H. K. Miller, N. C. Station	3.83	3.78	....	3.81	4.67	4.68	....	[1]4.72
C. H. Jones, Vt. Station	3.62	3.65	....	3.63	4.50	4.52	....	4.52
F. B. Bomberger, Md. Station	3.72	3.68	3.76	3.76	4.58	[1]4.83	4.58	[1]4.78
R. J. Davidson, Va. Station	3.74	3.74	....	3.75	4.61	4.46	....	4.49
A. W. Ogden, Conn. Station	3.58	....	3.67	3.66	4.41	4.50	....	4.42
C. S. Cathcart, Lister's Agricultural Chemical Works	3.72	3.76	3.74	....	4.58	4.52	4.59	....
H. E. Curtis, Ky. Station	3.79	3.83	3.77	3.78	4.48	[1]4.28	4.55	4.46
A. L. Emery, Uhlandt Fertilizer Works	3.83	3.82	3.79	3.84	4.65	4.63	4.50	4.66
J. P. Street, N. J. Station	3.68	3.72	....	3.69	4.49	4.52	....	4.50
Average	3.72	3.75	3.75	3.74	4.55	4.55	4.54	4.51
Theory	3.71	....	....	....	4.57	....	....	....

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[1] Not included in average.

COMMENTS OF ANALYSTS.

T. C. Trescot.—The data obtained by the Ulsch-Kjeldahl method were so unsatisfactory that no report is made of them.

A. L. Emery.—I am unable to understand why the Gunning method on sample 3 should run low. In other comparative results I have found it to agree very closely. I am very much pleased with the Ulsch-Gunning method. It is rapid and the reaction seems to be clean and complete in both low and high grade material.

A. W. Ogden.—The Gunning methods gave rather higher results on sample 2 than the Jodlbauer. These high results I believe are nearest correct and give us a point in favor of the sulphate of potash methods. In our regular fertilizers we have not found such a difference, and we conclude the sample must be extraordinary.

While there are no wide variations, the results by the Kjeldahl method, which is an official method of this association, are not entirely satisfactory. There is a variation of over 0.10 per cent in three results on No. 2 and in two on No. 3, which is greater than we usually expect by this method. The Gunning results are excellent, the greatest variation in No. 2 being 0.08 per cent and on No. 3, 0.06 per cent.

The results secured by both of the new methods are quite satisfactory. With the Ulsch-Kjeldahl method the greatest variation from theory on No. 2 is 0.12 per cent and on No. 3, 0.28 per cent. Six of the eight results on No. 2 vary less than 0.08 per cent and six of the nine results on No. 3 vary less than 0.10 per cent. With the Ulsch-Gunning method the greatest variation from theory on No. 2 is 0.13 per cent and on No. 3, 0.22 per cent. Two results vary by more than 0.10 per cent on No. 2 and three on No. 3. By eliminating the few wide results, we secure averages by the two methods almost identical on both samples. The results obtained by both of these methods are quite as good as those secured by the modified Kjeldahl method in both samples.

One hundred and ninety-four comparative tests have been made between the Ulsch-Kjeldahl and the official methods by Mr. L. H. Merrill, of the Maine Station, and the referee during the last two years. The averages secured by the two methods are identical by both methods. It is believed, however, that this method, as well as the Ulsch-Gunning method, may be further perfected, and the referee does not feel justified in recommending their adoption until a more general trial has been made.

III.—THE DETERMINATION OF THE AVAILABILITY OF ORGANIC NITROGEN.

Ten chemists signified a desire to receive samples for the study of the availability of organic nitrogen; of this number, seven have returned results.

It was the plan of the referee to make a further study of the pepsin-hydrochloric acid and the permanganate of potash methods. For this purpose ten samples of organic nitrogenous materials were prepared. These samples were carefully dried, ground, bottled and sealed as described in the earlier part of this report. A description of the samples follows:

No. 4. Dried blood.—A high-grade sample in good mechanical condition.

No. 5. Cotton-seed meal.—A fine yellow sample of the decorticated meal, containing 3.74 per cent phosphoric acid and 1.99 per cent potash.

No. 6. Dried ground fish.—Containing 8.02 per cent phosphoric acid.

No. 7. Tankage.—An average sample, containing 14.78 per cent phosphoric acid.

No. 8. Hoof meal, "E" brand.—A fine dry product.

No. 9. Raw leather.—Pure sole-leather shavings obtained from a local factory.

No. 10. Wool waste.—An unusually good sample of this product, containing 0.53 per cent phosphoric acid and 2.42 per cent potash.

No. 11. Bone sawings.—A hard, dry bone obtained from a button factory. It contained 25.42 per cent phosphoric acid.

No. 12. Steamed bone.—In very fine mechanical condition, and containing 26.92 per cent phosphoric acid.

No. 13. Raw bone meal.—An average sample, containing 22.70 per cent phosphoric acid.

The value of work of this kind is greatly enhanced by the use of vegetation cultures. With this idea in mind, the referee started twenty-four vegetation experiments with oats and fifteen with sweet potatoes. The oat crops were harvested on August 17, but the pressure of work has been so great that it has been impossible to make the analyses of the different crops. The sweet potato crops are still unharvested. In these vegetation tests portions of the samples of organic nitrogen sent out for analysis were used. It is unfortunate that this work could not be completed prior to this convention, and the referee is forced to defer any further report on it until our next meeting.

The ten samples selected were thought to fairly represent the most common sources of organic nitrogen. The blood, cotton-seed meal, fish, tankage, and hoof represented materials known to possess a high degree of availability, while the wool waste and raw leather were considered to have their nitrogen in a comparatively insoluble form. The three samples of bone were selected to furnish a comparison as to the availability of the nitrogen in the three main classes of ground bone. The first was a button bone which had been thoroughly dried and which contained little fatty matter. The second was a steamed bone of very fine mechanical condition, from which nearly all of the fatty matter had been extracted by the process of steaming, which also destroyed the cellular structure of the bone, and is supposed to render its ingredients more available to the plant. The sample of raw bone consisted of untreated bone; quite a large amount of fatty matter was present.

In sending out the samples the referee requested that four series of determinations should be made:

(1) Total nitrogen by the Kjeldahl method.
(2) The digestibility of the organic nitrogen in pepsin solution.
(3) The digestibility of the organic nitrogen in acid permanganate solution.
(4) The digestibility of the organic nitrogen in alkaline permanganate solution.

(1) TOTAL NITROGEN BY THE KJELDAHL METHOD.

Determination of organic nitrogen by Kjeldahl method.

Analysts.	Dried blood.	Cotton-seed meal.	Dried fish.	Tankage.	Hoof meal.	Raw leather.	Wool waste.	Bone sawings.	Steamed bone.	Raw bone.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
R. J. Davidson, Va. Station	13.98	7.23	8.80	6.32	14.11	[1]7.32	2.53	3.91	2.72	4.16
J. P. Street, N. J. Station	14.07	7.39	8.82	6.33	14.12	7.58	2.48	3.92	2.80	4.16
T. C. Trescot, U. S. Dept. of Agr	13.86	7.30	......	[1]6.09	[1]13.61	7.59	......	......	......	4.18
H. B. Slade, Me. Station	14.19	[1]7.60	......	6.42	13.95	7.65	......	......	......	4.08
O. W. Knight, Me. Station	14.08	7.46	......	6.33	13.97	7.40	......	......	......	4.08
L. M. Bloomfield, Ohio Station	......	7.28	[1]8.57	......	......	7.57	2.42	......	2.80	4.17
W. H. Heileman, Washington Station	......	......	8.73	......	[1]13.58	[1]7.21	2.66	3.95	2.80	......
Average	14.04	7.33	8.78	6.35	14.04	7.56	2.51	3.93	2.78	4.14

[1] Not included in averages.

COMMENTS OF ANALYSTS.

T. C. Trescot.—The nitrogen was determined in samples 4 and 8 by the regular methods and also by the absolute method of combustion in copper oxid. This method was also used with all the samples. The nitrogen as determined by the moist combustion process agreed very closely with that obtained by the combustion in copper oxid.

L. M. Bloomfield.—I made a number of redeterminations, using 0.5 gram of material and boiling about six hours. Though the duplicates do not agree as closely as I usually am able to get them, they are much better than the other results sent you. The boiling was evidently the fault. Not having had experience with materials of that kind, I had overlooked the fact that seems to be well established that they need prolonged treatment with the acid in order to get all of the nitrogen. The following are my new determinations:

Sample.	Per cent.	Per cent.
No. 5	7.42	7.70
No. 6	9.10	9.24
No. 9	7.28	7.56

The results of these analyses show quite clearly the necessity of careful manipulation in even such a reliable and well-established method as that of Kjeldahl. As a rule the chief difficulty seemed to be the analyst's inability to secure all the nitrogen in the sample. In every case but one, where there was a wide discrepancy, the results were too low. The low-grade samples, the three bones and the wool waste, occasioned little trouble, but the high-grade materials show variations not to be expected from the hands of experienced analysts. In blood the variation was 0.33 per cent; in cotton-seed meal, 0.37 per cent; in fish, 0.23 per cent; in tankage, 0.33 per cent; in hoof meal, 0.54 per cent, and in leather, 0.41 per cent. It is the belief of the referee that as a rule the low results were caused by insufficient digestion. It is well known that in analyzing such refractory materials as cotton-seed meal, hoof meal, and leather, it is necessary to digest for some time after the liquid becomes colorless. Failure to take this precaution is sure to cause low results.

(2) THE DIGESTION OF ORGANIC NITROGEN IN PEPSIN-HYDROCHLORIC ACID SOLUTION.

The method used was substantially the same as that given in the Report of the Connecticut Experiment Station for 1893, page 219.

TABLE I.—*Organic nitrogen indigestible in pepsin solution.*

Analysts.	Dried blood.	Cotton-seed meal.	Dried fish.	Tankage.	Hoof meal.	Raw leather.	Wool waste.	Bone sawings.	Steamed bone.	Raw bone.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
R. J. Davidson, Va. Station	0.42	0.84	1.96	1.60	6.63	4.51	1.73	0.10	0.45	0.36
	0.52	0.84	1.96	1.68	6.78	4.55	1.79	0.17	0.53	0.45
J. P. Street, N. J. Station	0.49	0.71	1.69	1.69	7.15	5.19	1.61	0.14	0.49	0.36
	0.54	0.88	1.76	[1]1.86	7.22	5.21	1.71	0.20	0.56	0.42
T. C. Trescot, U. S. Dept. of Agr	0.44	0.66	......	1.49	6.67	[1]3.75	......	......	......	0.39
H. B. Slade, Me. Station	[1]0.14	0.91	......	[1]2.48	[1]8.85	[1]5.65	......	......	......	[1]1.11
O. W. Knight, Me. Station	0.48	0.66	......	1.64	6.90	......	......	......	......	0.29
L. M. Bloomfield, Ohio Station	......	0.98	2.10	......	......	[1]3.85	1.82	......	[1]0.70	0.49
		[1]1.82	2.17	......	......	4.69	1.89	......	[1]1.05	[1]1.82
W. H. Heileman, Washington Station	......	......	1.64	......	[1]5.90	4.62	1.55	0.03	0.43	......
			1.66	......	[1]6.27	4.82	1.64	0.08	0.46	......
Average	0.48	0.81	1.87	1.62	6.89	4.80	1.72	0.12	0.49	0.39

[1] Not included in averages.

Five of the seven analysts obtained concordant results by this method. Two chemists report results widely divergent from the others. In one case the analyst seemed to have difficulty in securing closely agreeing duplicates, one set of results agreeing closely with those of other analysts, and the other being much too high. The other chemist failed to secure agreement with a chemist working in the same laboratory. It would appear, therefore, that these variations can not be charged to lack of uniformity in the samples or reagents, as the same were doubtless used in both cases, but to that old friend of the referees of this association, the personal factor.

To show the full significance of the results more clearly, the referee has recalculated them on the basis of the per cent of availability.

TABLE II.—*Availability of organic nitrogen in pepsin solution.*

Analysts.	Dried blood.	Cotton-seed meal.	Dried fish.	Tankage.	Hoof meal.	Raw leather.	Wool waste.	Bone sawings.	Steamed bone.	Raw bone.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
R. J. Davidson, Va. Station...	96.6	88.5	77.7	74.2	52.3	40.1	29.9	96.7	82.4	90.3
J. P. Street, N. J. Station.....	96.4	89.2	80.4	73.4	48.9	31.2	33.9	95.7	81.3	90.6
T. C. Trescot, U. S. Dept. of Agr..........................	96.8	91.0	......	76.5	52.5	[1]50.4	......	......	......	90.6
H. B. Slade, Me. Station......	[1]99.1	87.6	......	[1]61.0	[1]37.0	[1]25.3	......	......	......	[1]73.2
O. W. Knight, Me. Station ...	96.5	91.0	......	74.2	50.9	......	......	......	......	93.0
L. M. Bloomfield, Ohio Station	......	86.6	75.8	......	......	38.0	26.3	......	[1]68.7	88.2
W. H. Heileman, Washington Station	......	......	81.2	......	[1]56.7	37.6	36.7	98.7	84.2	......
Average...............	96.6	89.0	78.8	74.6	52.3	36.7	31.7	97	82.6	90.5
On basis of blood = 68.......	68	63	55	53	36	26	22	68	58	64
Vegetation cultures	68	74	69	61	67	2	31	......	60	......

[1] Not included in averages.

As was pointed out last year, a difference of a few hundredths makes quite a large difference when the results are calculated on this basis. For instance, the extreme variation in the cotton-seed meal from 86.6 per cent to 91 per cent is caused by a difference of but 0.32 per cent, while the variation in the leather of 8.9 per cent is due to a difference of but 0.57 per cent. When considered from this standpoint the results are remarkably uniform and show that this method will give concordant results in the hands of different analysts in different laboratories. The value of the method depends, however, on how far it is an interpreter of the actual results secured by the growing plant. As pointed out above, the referee was unable to finish his vegetation tests in time to secure data on this point. However, as the materials used were of average grade, except possibly the wool waste, which was an unusually good sample of that product, a rough comparison may be made with vegetation tests on the same class of materials by other workers. Using the results obtained by Dr. Jenkins, we find a fair agreement in all classes of goods except in the case of the hoof meal, whose vegetation test availability is 67 but whose pepsin availability is but 36. This fact merely emphasizes what has been noted by other workers, that the pepsin digestibility of hoof meal is no measure of its availability to the plant.

(3) THE DIGESTION OF ORGANIC NITROGEN IN PERMANGANATE OF POTASH SOLUTION.

Method in acid solution.—Weigh 1 gram of material into a 500 cc flask, add a little paraffin and 100 cc of permanganate solution (consisting of 16 grams of potassium permanganate and 100 cc of concentrated c. p. sulphuric acid to the liter). Connect with distilling apparatus and heat at a low temperature just below boiling for one hour. Then add 50 cc of saturated sodium hydrate solution, distill for thirty minutes, and titrate as usual.

Method in alkaline solution.—Weigh 1 gram of material into a 500 cc flask, add a little paraffin and 100 cc of permanganate solution (consisting of 16 grams of potassium permanganate and 300 cc of saturated sodium hydrate solution to the liter). Connect as before and heat below boiling for one hour. Then increase the temperature and distill for thirty minutes as above.

TABLE III.—*Availability of nitrogen in alkali permanganate.*

Analysts.	Dried blood.	Cotton-seed meal.	Dried fish.	Tankage.	Hoof meal.	Raw leather.	Wool waste.	Bone sawings.	Steamed bone.	Raw bone.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
R. J. Davidson, Va. Station...	42.2	38.1	49.8	55.3	46.6	24.6	69.3	7[illegible].9	78.8	76.1
J. P. Street, N. J. Station.....	26.6	23.9	23.9	29.4	25.2	9.3	33.9	54.4	49.3	44.0
T. C. Trescot, U. S. Dept. of Agr.....................	60.9	64.3	......	76.1	67.9	43.3	......	......	......	82.6
H. B. Slade, Me. Station......	......	......	......	......	......	......	......	......	......	......
O. W. Knight, Me. Station....	31.8	31.8	......	48.5	39.6	17.2	......	......	......	78.0
L. M. Bloomfield, Ohio Station	......	30.6	32.8	......	......	19.4	58.6	......	68.0	62.6
W. H. Heileman, Washington Station..................	......	......	29.8	......	28.7	12.6	50.2	68.2	63.7	......

TABLE IV.—*Availability of nitrogen in acid permanganate.*

Analysts.	Dried blood.	Cottonseed meal.	Dried fish.	Tankage.	Hoof meal.	Raw leather.	Wool waste.	Bone sawings.	Steamed bone.	Raw bone.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
R. J. Davidson, Va. Station...	42.9	42.3	53.5	64.4	46.4	29.1	62.9	79.9	77.7	77.7
J. P. Street, N. J. Station.....	38.7	36.6	48.9	62.4	42.3	21.2	61.8	74.3	73.4	71.3
T. C. Trescot, U. S. Dept. of Agr.....................	53.1	65.8	......	66.1	51.7	55.3	......	......	......	74.4
H. B. Slade, Me. Station......	35.2	32.7	......	58.0	49.0	22.5	......	......	......	69.3
O. W. Knight, Me. Station....	34.7	31.1	......	56.4	33.5	17.6	......	......	......	70.0
L. M. Bloomfield, Ohio Station	......	30.6	31.9	......	......	18.5	61.4	......	70.5	54.1
W. H. Heileman, Washington Station..................	......	......	40.2	......	35.7	16.1	38.6	63.1	61.9	......

There is an utter lack of agreement in the results by these two methods, especially where the alkaline permanganate is used. The referee was unable to test this method thoroughly before sending out the instructions, and in this way certain possible sources of error escaped his attention which would have been otherwise noticed. In the work with this method last year, Mr. R. J. Davidson and the referee were the only chemists who reported results, and their work was upon a limited number of materials. Their results agreed quite closely and compared well with the vegetation tests in the same samples. The acid solution appeared to be particularly promising.

After making a number of tests this year, it became evident to the referee that the method as suggested was a difficult one to control. The directions provided that during the digestion the solutions should be heated just below boiling. This was found to be almost an impossibility, and it was very difficult to maintain uniform conditions in two different sets of tests. It is more than likely, therefore, that this inability to control the temperature and keep it uniform is in a large measure responsible for the poor agreement of the results. A study of the table shows, however, that notwithstanding this failure to agree with each other, the results of the different analyses, if taken separately, show a very decided uniformity in the relative availability of the different organic forms. The three forms of bone were found to be the most available, while the others followed in this order: tankage, wool waste, fish, hoof meal, blood, cotton-seed meal, and leather. These results were far from satisfactory, as it was known that with the exception of the leather the order of their availability should be almost reversed.

AVAILABILITY OF NITROGEN TAKEN IN EQUAL AMOUNTS.

It then occurred to the referee that the difficulty might be obviated were the same amount of organic nitrogen used in each determination instead of the same amount of material. Accordingly a new series of determinations was made, where an amount of organic nitrogen equivalent to that contained in one gram of cotton-seed meal was taken in each case. The results of these analyses follow:

TABLE V.—*Availability of nitrogen in equal amounts.*

Substances.	Amount taken.	Availability.	Amount taken.	Availability.
	Grams.	*Per cent.*	*Grams.*	*Per cent.*
Dried blood	1	26.6	0.5	26.9
Cotton-seed meal	1	23.9	1.0	21.0
Dried fish	1	23.9	.8	23.7
Tankage	1	29.4	1.2	26.7
Hoof meal	1	25.2	.5	32.9
Raw leather	1	9.3	1.0	9.2
Wool waste	1	33.9	3.0	25.1
Bone sawings	1	54.4	1.9	31.1
Steamed bone	1	49.3	2.6	26.8
Raw bone	1	44.9	1.8	30.5

The relation shown by these results was much more in accord with the vegetation tests, and the results appeared to determine quite closely the relative availability of the different forms.

The failure of the method in the hands of different analysts led the referee to attempt to devise some method whereby the conditions could be controlled more accurately. It was suggested by the Maine Station that a 3 per cent neutral solution of permanganate be used and that the digestion take place on a steam bath. Acting on this suggestion, the referee adopted the following line of treatment, and secured very promising results.

Method.—Weigh 1 gram of material into a 500 cc Erlenmeyer flask; add 100 cc of neutral 3 per cent permanganate of potash solution, and digest on a steam bath for thirty minutes, shaking occasionally to moisten any particles of the material adhering to the sides of the flask. Add 200 cc of cold water, and filter and wash three or four times, using from 125 to 150 cc of water. Determine the total nitrogen in the undigested residue by the ordinary Kjeldahl method.

In the first tests by this method an attempt was made to filter the solutions while still hot, but it was found that aside from the difficulty of handling a hot solution the great concentration of the liquid made the filtration very tedious. It was demonstrated by comparative results, as will be noted later, that dilution of the solution gave even better results, and this practice was employed in all subsequent tests by this method.

In the following table are also incorporated some tests made by Mr. H. B. Slade, of the Maine Station. In his report Mr. Slade did not specify the method of filtration used, and it is assumed that it was carried on while the solutions were still hot. The calculations are made on the basis of per cent of availability.

TABLE VI.—*Availability of nitrogen in equal amounts.*

Substances.	Street.	Slade.	Average.
	Per cent.	*Per cent.*	*Per cent.*
Dried blood	95.3	94.3	94.8
Cotton-seed meal	92.5	89.4	91.0
Dried fish	92.8	....	92.8
Tankage	94.5	95.0	94.8
Hoof meal	93.9	91.3	92.6
Raw leather	64.2	26.5	45.3
Wool waste	90.8	....	90.8
Bone sawings	91.6	....	91.6
Steamed bone	92.1	....	92.1
Raw bone	86.2	94.1	90.2

A study of the table shows a very marked difference between the availability of the leather and the other materials, the availability ranging from 94.8 per cent in the case of the blood to 45.3 per cent in the case of the leather. The wool waste shows an availability of 90 8 per cent, higher than one would expect, but, as was pointed out earlier in the report, this sample was an unusually good product and probably does not fairly represent the average wool waste on the market. It is impossible to draw any positive conclusions from these results without vegetation tests as a basis of comparison, but it is believed that further study of this method, possibly with variations in the strength of the permanganate solution, may point out a chemical method which will secure results in close accord with vegetation cultures.

RECOMMENDATIONS.

(1) That the Ulsch-Street method for nitric nitrogen be made an official method.

(2) That the study of the Ulsch-Kjeldahl and Ulsch-Gunning methods for total nitrogen in the presence of nitrates be continued next year.

(3) That the permanganate of potash method for determining the availability of organic nitrogen be further studied next year, with especial reference to materials of known inferiority.

COMMITTEE ON RECOMMENDATIONS—DISCUSSION ON NITROGEN.

Upon the conclusion of Mr. Street's paper the chair appointed the following committee upon recommendations: Messrs. Bartlett, Wheeler, Scovell, Van Slyke, and Hite.

Mr. WINTON. I would like to say a word with regard to this Ulsch-

Gunning or Fassbänder-Gunning method, as we have been accustomed to call it. This method has given very good results indeed at our station. We have tried it during the past year on every nitrate-containing fertilizer that has come into our laboratory, and it has given very good satisfaction on all samples, with a few exceptions. You will notice that the samples the referee sent out contained in no case more than 1¾ per cent of nitric nitrogen. On such samples of fertilizers the method is perfectly satisfactory. The time of digestion, in our experience, has been a little more than half that required in the modified Kjeldahl method. It seems to meet every requirement in the case of such samples, but when the percentage gets up to 3, 4, or 5, or higher, it is not at all accurate. We lose several tenths of a per cent of nitrogen. This point was brought out by Mr. Ogden, of our station, some years ago in connection with the Ulsch method. He found that 2 grams of iron would not give him theoretical results on pure salts where the percentage was 15 or 16; that is, when the nitric nitrogen present was as much as .07 gram. In such cases it required more iron. Of course, it naturally followed in this Ulsch-Gunning method, which is merely the Ulsch method carried a little further, that a larger quantity of iron was necessary, so that in these exceptional samples, with more than 3 per cent of nitric nitrogen, we were obliged to use more iron. We did it reluctantly, because the extra amount very materially interferes with the distillation and causes bumping too early in the process. We made numerous experiments with various quantities of acid to see if it were not possible to get along with a smaller amount, but we were not successful. Working on pure nitrate of potash in half-gram portions, in no case was I able to get over 13.30 per cent, whereas the theoretical per cent was 13.80, or a loss of one-half of 1 (0.5) per cent. So it seems necessary in such cases to use a larger quantity of iron. Now, I think 3 grams of iron will meet every possible case likely to be encountered in the analysis of mixed fertilizers, but our experiments show that when the percentage of nitrogen is as high as 7, even that quantity is insufficient. But such fertilizers are not likely to be encountered. I think, however, it will be well if in the ensuing year the point can be taken into consideration whether or not it is desirable to modify the method in such a way as to give results for fertilizers containing high percentages of nitrogen.

I want to say a word as to the availability of nitrogen in different solutions. It seems to me that the pepsin solution tells a better story than any of these other solutions. For example, you are probably familiar with the work that has been done at the Connecticut Station on a variety of substances, and if you remember those results, they showed that while dried blood and cotton-seed meal did not give as high as 96.89 per cent available nitrogen, nevertheless, with the pepsin solution, a better clew to the available organic nitrogen in these substances was obtained than by any other reagent that had been used.

The point I wish to make is, that although this pepsin solution will not coincide, percentage for percentage of available nitrogen, at all closely with actual results obtained from pot experiments, yet it gives much better results than other solutions.

With anything that has somewhere about 80 or 90 per cent of available nitrogen the pepsin solution will show a very high percentage when tested with pot experiments. When we came to wool waste and raw leather we found the pepsin solution in a pot experiment gave much lower results than that. Now, Dr. Jenkins has proved that raw leather contains not over 6 to 7 per cent available nitrogen. In experiments conducted at our station for two years on raw leather, we found just the same thing, whereas the availability is as high as 36 per cent. So we established the rule that anything under 50 per cent, using the pepsin solution, would be considered nonavailable, but anything running above 50 per cent, with the pepsin solution, would be available. The pepsin solution, considered in that way, gave us a very good idea of the relative availability of different organic matters.

The PRESIDENT. I did not notice that you said anything with reference to hoof meal.

Mr. WINTON. There was one case where it did not work. I think hoof meal was proved by pot experiments to be quite valuable. Taken in a general way, the pepsin solution seemed to be the best thing we could employ for the purpose. I think it does give us a very good clew to the available organic nitrogen.

Mr. STREET. The chief reasons for seeking another method for determining the availability of nitrogen were, first, that in the case of this hoof meal we got entirely too low availability by the pepsin, and the leather was entirely too high, and, secondly and chiefly, that it takes a great amount of time. It requires twenty-four hours digestion.

Mr. LINDSEY. It seems to me that the acid permanganate and alkali permanganate did not tell a very straight story.

Mr. STREET. They are no good at all.

Mr. Ewell offered the following resolution:

Resolved, That henceforth in reporting results of trials of methods the following data are to be included:

Number of determinations by each analyst.
Maximum of determinations by each analyst.
Minimum of determinations by each analyst.
Average of determinations by each analyst.

The attention of the referee to be called to the fact that the general averages should be calculated from the sum of all the determinations and not from the sums of averages for individual analysts.

Referred to the committee on recommendations.

REPORT OF COMMITTEE ON RECOMMENDATIONS.

The report of the committee on recommendations was then called for and read by Mr. Bartlett.

The committee recommends that—

1. The Ulsch-Street method for determination of nitric nitrogen, as recommended by referee, be made an official method.
2. That the Ulsch-Kjeldahl or Ulsch-Gunning method be further investigated.
3. That the referee and members of the association devote what time there may be available to devising and perfecting a rapid method of determining available nitrogen in mixed fertilizers, and that the referee call the attention of members to the subject in sending out his directions for work.

Mr. Van Slyke moved that the first recommendation be adopted; viz, that the Ulsch-Street method for nitrogen be made an official method. Adopted.

Mr. Huston moved that the second recommendation be adopted; viz, that the Ulsch-Kjeldahl or Ulsch-Gunning method be made the subject of further study. Adopted.

Mr. Van Slyke moved the adoption of the third recommendation; viz, that the study of a rapid method for determining available nitrogen be earnestly commended to both referees and members of the association.

Mr. **Wiley**. I have no vote on this question, but perhaps I may say that rapidity is not the only thing to be considered. Would it not be well to say "a rapid and reasonably reliable method?"

The Chair reminded the association that only those members actually concerned with fertilizer control work were entitled to vote upon these matters of fertilizer analysis.

Mr. Persons asked if the association could not allow those chemists who were in charge of fertilizer work at stations, though not actually official State chemists, to vote upon these questions. The Chair referred Mr. Persons to the history of this restriction on voting, stating that it had been made upon good grounds, and that if he would look up the records he would probably not be disposed to criticise this clause.

The recommendation was thereupon adopted.

Mr. **Bartlett**. We have no further recommendation with regard to this matter of available nitrogen.

After some discussion, it was agreed that the hours for meeting should be from 9.30 a. m. to 12.30 p. m., and from 2 to 4.30 p. m.

The report on potash was read by Mr. Winton, as follows:

REPORT ON POTASH.

By A. L. Winton, *Referee*, and C. H. Jones, *Associate Referee*.

The work of the present year has been carried out with the cooperation of the following chemists: Mr. G. E. Patrick, United States Department of Agriculture, Division of Chemistry, Washington, D. C.; Mr. A. M. Peter, Kentucky Experiment Station, Lexington, Ky.; Mr. F. B. Bomberger, Maryland Agricultural College, College Park, Md.; Mr. A. W. Blair, North Carolina Experiment Station, West Raleigh, N. C.; Mr. B. L. Hartwell, Rhode Island Experiment Station, Kingston, R. I.; Mr. F. S. Shiver, South Carolina Experiment Station, Clemson, S. C.

The subjects which have been investigated are:

(1) The Stassfurt methods for determination of potash.

(2) The "optional" method, acidulating with hydrochloric acid before precipitating the sulphuric acid.

(3) The determination of potash by the Lindo-Gladding method, evaporating directly with platinum solution, without previous removal of lime.

(4) Quantities of platinum solution necessary for determinations in German potash salts.

Preparation of Materials.

A sufficient quantity of the materials used in the study of potash methods in 1896 remained for the determinations of the present year. These materials, as was fully described in the report on potash last year, consisted of pure potassium chlorid, pure potassium sulphate, and mixtures representing the impurities in each of the four manure salts commonly sold in the United States. The "impurities" were distributed in vials in quantities corresponding to 10 grams of the commercial salts of average composition. The total contents of each vial were boiled by each analyst with water, made up to a definite volume and filtered. By mixing, in the proper proportions, aliquots of this solution with weighed portions of the pure potash salts, solutions for analysis were obtained which represented definite quantities of the commercial salts.

Details as to quantities are given in the following table:

Quantities of samples.

Impurities.	Solution of "impurities" made up to—	Equivalent to 0.5 gram of the Stassfurt salt.	
		Solution of "impurities."	Pure potash salt.
	cc.	*cc.*	*Gram.*
Muriate of potash	500	25	0.42 KCl
Sulphate of potash 90 per cent	400	20	.46 K_2SO_4
Sulphate of potash and magnesia	400	20	.26 K_2SO_4
Kainit	125	6¼	.14 K_2SO_4

In making comparative determinations by the Lindo-Gladding method, as applied to kainit, samples of the commercial salt, as well as artificial mixtures, have been used.

(1) The Stassfurt Methods.

Through the courtesy of Dr. B. von Herff, of the New York office of the potash syndicate, copies of the description of the Stassfurt methods, printed in the German language, were secured for distribution among the chemists participating in the investigation of the methods.

The following translation was specially prepared by Dr. von Herff for publication in this report. The footnotes were communicated by chemists of the syndicate:

DESCRIPTION OF METHODS OF ANALYSIS AGREED UPON AND ADOPTED BY THE STASSFURT POTASH INDUSTRY.

A.—*Method for the Determination of Potash in the Concentrated Salts.*

(1) *Muriate of potash.*

(*a*) *Determination of potassium chlorid.*

Of the finely ground substance, 7.6405 grams are dissolved and the solution made up to 500 cc. If the sample contain more than 5 per cent of sulphuric acid (SO_3) it will be necessary to transform the sulphates to the corresponding chlorin compounds by precipitating with acidulated solution of barium chlorid. Twenty cubic centimeters of the filtrate (= 0.3056 gram substance) are evaporated with a 5 cc platinum chlorid solution upon the water bath in a shallow porcelain dish of about 10 cm diameter. The evaporation is facilitated by stirring, and is carried to the point where the thick liquid rapidly crystallizes upon cooling.[1] The dry residue is finely ground with a glass pestle, then stirred up with 20 cc of alcohol and poured upon the filter, which has previously been weighed (while warm) after drying at 120° to 130° C. One hour's drying will usually be found necessary. The filter should first be moistened with alcohol, and care should be taken not to pour any of the liquid upon the rim of the filter. The filtration may be accelerated by the weak action of a suction pump.[2] The potassium platinum chlorid can be readily and completely washed upon the filter. The precipitate is freed from the alcohol as much as possible by suction and by pressing between filter papers; it is then dried at 120° to 130° until its weight is constant. This will require about twenty minutes. One milligram potassium platinum chlorid corresponds to 0.1 per cent potassium chlorid.

(b) *Determination of chlorid of sodium.*

Twelve and a half grams chlorid of potassium are dissolved in a 250 cc flask by boiling with 25 cc water, to which a little potassium carbonate has been added in order to transform the compounds of magnesium and calcium into carbonates. The flask is filled up to the mark with absolute alcohol. One hundred cubic centimeters of the filtrate (= 5 grams of the substance) are evaporated to dryness in a porcelain or platinum dish, after a few drops of the concentrated hydrochloric acid have been added to transform the potassium carbonate, which might be present, into potassium chlorid; the residue is heated to a low redness and weighed. In this mixture of the chlorids of potassium and sodium, either chlorid of potassium is determined after the common method with platinum chlorid and sodium chlorid, calculated from the difference, or it is determined by titrating the mixed alkalies with one-tenth normal silver solution.

(c) *Determination of chlorid of magnesium.*

Twenty-five grams of chlorid of potassium are dissolved in a 500 cc flask, and 10 cc of normal potash solution are added. The contents of the flask are made up to the mark, and 50 cc of the filtrate are titrated with one-tenth normal sulphuric acid. The soluble compounds of calcium present do not influence the result.

(2) *Determination of sulphate of potassium and sulphate of potassium magnesium.*

(a) *Determination of potassium sulphate.*

Dissolve 8.9235 grams of the finely ground substance in a 500 cc flask with about 350 cc boiling water, to which 20 cc of concentrated hydrochloric acid have been added. The sulphuric acid is precipitated by slowly adding barium chlorid solution (from a burette with glass cock) to the boiling liquid. The precipitation of the sulphuric acid is completed if the clear solution do not become turbid by the addition of a small fragment of barium chlorid. This is a very accurate test. If an excess of barium chlorid have been added, it must be precipitated with sulphuric acid. After completing the precipitation and cooling, the flask is filled up to the mark and 20 cc of the filtrate (= 0.357 gram of the substance) are treated as usual with 5 cc of platinum chlorid solution. One milligram K_2PtCl_6 corresponds to 0.1 per cent K_2SO_4. Three-tenths of 1 per cent are to be added to the result obtained in the analyses of sulphate of potash, while in the analyses of sulphate of potash-magnesia no correction is necessary.[3]

(3) *Determination of potassium chlorid and potassium sulphate in calcined manure salts.*

(a) *Determination of potassium chlorid and potassium sulphate.*

Dissolve 15.281 grams of the sample (for the determination of muriate of potassium) or 17.847 grams (for the determination of sulphate of potassium) in a 500 cc flask with water, to which 10 cc of concentrated hydrochloric acid have been added. The flask is filled up to the mark, the contents filtered, and 250 cc (=7.6405 and 8.9235 grams, respectively) of the filtrate are treated in a 500 cc flask with barium chlorid solution in the same manner as in the determination of potassium sulphate.

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[1] It is advantageous to evaporate the solution to complete dryness in case it contains potassium platinum chlorid and sodium platinum chlorid only, because the sodium platinum chlorid is thereby rendered free of all water, and in this form it is more soluble in absolute alcohol, or in alcohol of 96 per cent.

[2] For the chemist with little experience, it is advisable to grind the precipitate once or twice with fresh quantities of alcohol after the first washing liquid has been poured off.

[3] In order to obtain accurate results it is absolutely necessary to follow the described method in all details. Results will be unreliable and more troublesome corrections will be needed if the liquid be either more diluted or more concentrated, or if the sulphuric acid be precipitated from a solution which is either very slightly acid or even neutral, or if the boiling during precipitation be interrupted.

B.—*Method for Determination of Magnesium Sulphate in Kieserit.*

Ten grams of the finely ground substance are boiled for at least an hour in a 500 cc flask about two-thirds full of water. After cooling, from 50 to 60 cc of double normal potash solution and 20 cc (1:10) neutral potassium oxylate solution are added. The flask is filled up to the mark, and the liquid filtered, after standing for a quarter of an hour. The excess of alkali in the filtrate is titrated with one-tenth normal sulphuric acid, and 0.2 per cent are to be added to the sulphate of magnesia obtained.

C.—*Methods of Analysis of Crude Potash Salts (Carnallit, Kainit, Sylvinit, and Bergkieserit).*

(*1*) *Preparation of sample.*

It is recommended to grind a large sample of at least 0.5 kg in weight in a mill or mortar, in order to avoid differences resulting from coarse grinding.

(*2*) *Determination of potash by the precipitation method.*

Dissolve 35.70 grams of kainit or sylvinit, or 30.56 carnallit or bergkieserit, in a 500 cc flask, with about 350 cc boiling water, to which 10 cc hydrochloric acid have been added. After cooling, the flask is filled up to the 500 cc mark, 50 cc of the filtrate are precipitated in a 200 cc flask with barium chlorid in the usual manner, and 20 cc (=0.3570 gram, 0.3056 gram substance, respectively) are evaporated with 5 cc platinum chlorid solution, and further treated according to the common method.[1]

(*3*) *Complete analysis of the crude potash salts.*

For this purpose, 100 grams of the substance are dissolved by boiling with about 500 cc water. The solution is filtered, the residue and filtrate washed, and the filtrate and wash waters made up to 1 liter. A portion of the liquid serves for the determination of sulphuric acid, according to the common method, by precipitating with barium chlorid; another portion serves for the determination of lime and magnesia. For the determination of the alkaline chlorids 100 cc of the solution (=10 grams of the substance) are acidulated with hydrochloric acid, heated to boiling, and the sulphuric acid completely precipitated with barium chlorid in a 500 cc flask, avoiding an excess of the barium solution. Fifty cubic centimeters of this liquid (=1 gram substance) are evaporated to dryness in order to drive off the hydrochloric acid, and thereafter magnesium chlorid is decomposed by igniting with oxalic acid. After the ignition, the residue is moistened with a little ammonium carbonate in order to transform the calcium oxid into calcium carbonate. In the mixture of the chlorids of the alkalies, which are now entirely free from lime and magnesia, potassium chlorid is determined by evaporating with 10 cc platinum chlorid solution. The weight of the sodium chlorid is obtained by subtracting potassium chlorid from the mixed alkalies.

In calculating the results obtained from kainit and sylvinit, the sulphuric acid combined with calcium is first subtracted from the total amount of soluble sulphuric acid. The remainder of the sulphuric acid is calculated to potassium sulphate and magnesium sulphate, according to the molecular proportion in which these salts are present in kainit and schoenit. If, after this calculation, some potassium remain uncombined with sulphuric acid, it is to be reckoned as potassium chlorid. Likewise the remainder of the magnesia, uncombined with sulphuric acid, is to be reckoned as magnesium chlorid. The result of the calculation will show how much potassium is present on one hand in the form of kainit, K_2SO_4, $MgSO_4$, $MgCL_2 + 6H_2O$, and schoenit, K_2SO_4, $MgSO_4 + 6H_2O$, and, on the other hand, in the form of potassium chlorid. Sodium is reckoned as chlorid of sodium.

In carnallit and bergkieserit calcium oxid is calculated to sulphate of calcium, and the remainder of the sulphuric acid, not combined with calcium, is to be reckoned as sulphate of magnesium. Magnesia uncombined with sulphuric acid is to be reckoned as magnesium chlorid.

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[1] To be more particular, it is recommended here to take a rather larger quantity of platinum chlorid, say 6 to 7 cc, and also to pay attention to the footnote No. 2, page 31.

D.—*Determination of Water.*

The content of water in chlorid of potassium and in the other concentrated salts is determined by heating 10 grams of the sample in a covered platinum crucible for about ten minutes, with a small flame to dark-red heat. In the analysis of salts which are rich in magnesium chlorid care should be taken to avoid the decomposition of that constituent. This can be effected by covering the substance with freshly ignited lime,[1] or else the loss of chlorin should be determined by double titration, paying attention at the same time to the absorption of oxygen. The loss in weight is to be subtracted from the result obtained in the determination of water.

APPENDIX.

(1) *Preparation of the solution of platinum chlorid.*

The recovery of the platinum from the alcoholic wash liquids containing potash salts, and also from the precipitates of potassium platinum chlorid, is carried out in a large porcelain dish upon the water bath. The alcoholic liquid, after being diluted with about one-third of water, is heated to boiling, sodium carbonate is added, and at the same time the precipitates of potassium platinum chlorid are put in the reducing liquid in small portions at a time. The heating upon the water bath should be continued until the alkaline liquid, covering the precipitated platinum, is perfectly clear. Its color should be only of the faintest yellow. After pouring off the liquid, the reduced platinum is cleansed by boiling with hydrochloric acid and water. It is then dried upon the water bath and ignited for the purpose of destroying organic compounds. It is a good plan to heat the finely ground platinum once with pure concentrated nitric acid, which is to be poured off. The platinum is dissolved in a large porcelain dish upon the water bath by first heating with about four times its weight of pure concentrated hydrochloric acid, to which nitric acid (in proportion of four parts of hydrochloric acid to one of nitric acid) is gradually added. After the solution is completed, it is to be evaporated until a drop taken out with a glass rod solidifies on cooling. The solution of platinum chlorid is allowed to cool, and will then form a crystalline cake, which is dissolved in water, filtered, and diluted, so that 1 gram of platinum is contained in 10 cc of solution (sp. gr. 1.18). Special care must be taken that the solution is free from subchlorid of platinum as well as from nitrogen compounds. Platinum subchlorid may be converted into platinum chlorid by means of fuming hydrochloric acid and a little nitric acid. The nitrogen compounds are destroyed by repeated additions of hydrochloric acid and water during evaporation. If platinum scraps have been used for making platinum chlorid, it should be freed from iridium by precipitating the platinum chlorid solution with ammonium chlorid and again reducing the precipitate. The testing of the purity of the platinum chlorid solution is most conveniently performed by using potassium chlorid prepared from chemically pure materials.

(2) *Preparation of barium chlorid solution.*

One hundred and twenty-two grams of crystallized barium chlorid are dissolved with water and 50 cc concentrated hydrochloric acid and diluted to 1,000 cc.

(3) *Alcohol.*

Alcohol for washing the platinum precipitate should be of at least 96 per cent strength.

(4) *Filter.*

For filtering potassium platinum chlorid, the Swedish filter Munktell 1 F. is best suited.[2]

The following special instructions were sent out by the referees:

INSTRUCTIONS FOR TESTING THE METHODS.

The analyst should first familiarize himself with the method of precipitating $BaSO_4$, working on solutions prepared as directed from any samples of real Stassfurt salts.

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[1] Or with lead oxid.

[2] Or else the Gooch crucibles with asbestos may be employed for the purpose.

Muriate of potash.—Weigh out accurately from a weighing tube about 0.25 gram, KCl, c. p., add 15 cc muriate of potash "impurities" and 5 cc of water. Evaporate with 5 cc of platinum solution and proceed otherwise according to A, 1, a. Make blank on reagents and "impurities."

Sulphate of potash.—Weigh out exactly 3.2838 grams K_2SO_4, c. p. Transfer to a 200 cc flask, add 143 cc sulphate of potash "impurities" and 8 cc HCl concentrated. After precipitating $BaSO_4$, as directed under A, 2, make up to 200 cc, filter through dry paper and proceed with 20 cc as further directed.

Sulphate of potash and magnesia.—Weigh out exactly 1.8561 grams K_2SO_4, c. p. Transfer to a 200 cc flask, add 143 cc sulphate of potash and magnesia "impurities" and 8 cc HCl concentrated and proceed as with sulphate of potash.

Kainit.—Weigh out exactly 0.9996 gram K_2SO_4, c. p. Transfer to a 200 cc flask, add 45 cc kainit "impurities," 1 cc HCl concentrated, and 4 cc water. Precipitate SO_3 and proceed as directed under C, 2.

Make blank determinations on reagents (not impurities) used in the analysis of the preceding three salts as follows: Place in a 200 cc flask the quantities of $BaCl_2$ solution and HCl which were used in the actual analysis. Add water so the bulk of liquid will be 150 cc and heat to boiling. Add dropwise slight excess of pure H_2SO_4 (which should leave no residue on evaporation); allow to stand some time, make up to the mark, and filter through dry paper. Evaporate 20 cc, drive off H_2SO_4, add water and 1 cc HCl concentrated. Proceed with evaporation with platinum solution, treatment with alcohol, etc., as in the actual analysis.

For filtering and weighing the K_2PtCl_6 use Gooch crucibles in all cases.

In testing the method for muriate of potash, it was possible to weigh out the KCl needed for each determination and add to it the proper quantity of the solution of "impurities," thus avoiding the errors and waste of materials incident to making up a larger amount to a definite volume and removing aliquot portions.

This could not be done in the other cases, but a saving of materials was effected by using smaller quantities and making up to correspondingly smaller volumes. The aliquot portions, after precipitation of $BaSO_4$, in all cases represented the same quantities of material as they would if the normal quantities had been used.

The determination of the potash in the reagents and "impurities" together represented certain difficulties in the case of the salts containing sulphates, and as the quantities in the "impurities" were too small to be considered, only blanks on the reagents were made.

The analytical data obtained by the several analysts, together with calculated results, are given in Tables I and II.

Before converting to KCl or K_2SO_4, the total K_2PtCl_6 found in each determination was first corrected for the amount found in the average of the blank determinations by the same analyst. As directed in the description of the method, the old conversion factors (0.3056 to KCl and 0.3570 to K_2SO_4) were employed. In the case of sulphate of potash, 90 per cent of the weights of K_2SO_4 found were corrected by adding 0.0011 gram, corresponding to the correction of 0.3 per cent, which, according to the directions, should be made in the analysis of this salt.

TABLE I.—*Determination of potassium chlorid by the Stassfurt method.*

[Old factors.]

Substances and analysts.	KCl (dry) taken.	K_2PtCl_6 total found.	K_2PtCl_6 reagents and "impurities."	KCl found.	KCl error.	K_2O error.
	Gram.	*Gram.*	*Gram.*	*Gram.*	*Gram.*	*Gram.*
Potassium chlorid, c. p.:						
A. W. Blair	0.2489	0.8225	0.0060	0.2495	+0.0006	+0.0004
	.2489	.8236	....	.2499	+ .0010	+ .0006
	.2480	.8202	....	.2488	— .0001	— .0001
	.2489	.8176	....	.2480	— .0009	— .0005
Muriate of potash. (KCl, c. p. + impurities):						
G. E. Patrick	.2400	[1].7843	....	.3397	— .0003	— .0002
	.2404	[1].7848	....	.2398	— .0006	— .0004
	.3469	[1]1.1329	....	.3462	— .0007	— .0004
	.4945	[1]1.6156	....	.4937	— .0008	— .0005
	.2787	[1].9102	....	.2782	— .0005	— .0003
	.2832	[1].9215	....	.2816	— .0016	— .0010
	.2953	[1].9662	....	.2953	.0000	.0000
	.2815	[1].9202	....	.2812	— .0003	— .0002
	.2551	[1].8401	....	.2567	+ .0016	+ .0010
	.2701	[1].8820	....	.2695	— .0006	— .0004
	.2461	[1].8030	....	.2454	— .0007	— .0004
	.2836	[1].9267	....	.2832	— .0004	— .0003
A. M. Peter	.2489	.8157	.0005	.2491	+ .0002	+ .0001
	.2489	.8161	....	.2492	+ .0003	+ .0002
F. B. Bomberger	.2421	.7953	.0053	.2414	— .0007	— .0004
	.2424	.7976	....	.2421	— .0003	— .0002
	.2516	.8281	....	.2514	— .0002	— .0001
	.2573	.8459	....	.2569	— .0004	— .0003
A. W. Blair	.2489	.8312	.0095	.2511	+ .0022	+ .0014
	.2489	.8320	....	.2514	+ .0025	+ .0016
F. S. Shiver	.2495	.8195	.0020	.2498	+ .0003	+ .0002
	.2511	.8247	....	.2514	+ .0003	+ .0002
C. H. Jones	.2556	.8370	.0045	.2544	— .0012	— .0008
	.2556	.8400	....	.2553	— .0003	— .0002
	.2556	.8374	....	.2545	— .0011	— .0007
	.2556	.8394	....	.2551	— .0005	— .0003

[1] Corrected by blanks with impurities and reagents.

TABLE II.—*Determination of potassium sulphate by the Stassfurt method.*

[Old factors.]

Substances and analysts.	K_2SO_4 taken.	K_2PtCl_6 total found.	K_2PtCl_6 from reagents.	K_2SO_4 found.	K_2SO_4 error.	K_2O error.
Potassium sulphate c. p.:	*Gram.*	*Gram.*	*Gram.*	*Gram.*	*Gram.*	*Gram.*
A. W. Blair	0.3284	0.9532	0.0088	0.3383	+0.0099	+0.0054
	.3284	.9529	.0096	.3381	+ .0097	+ .0052
	.3284	.9553	.0081	.3390	+ .0106	+ .0057
	.3284	[1].9081	....	[1].3222	— .0062	— .0033
	.3284	[2].9083	....	[2].3222	— .0062	— .0033
	.3284	[3].9110	....	[3].3232	— .0052	— .0028
	.3284	[4].9025	[4].0076	[4].3206	— .0078	— .0042
	.3284	[4].9023	....	[4].3205	— .0079	— .0042
C. H. Jones	.3570	.9920	.0030	.3542	— .0028	— .0015
	.3570	.9950	....	.3552	— .0018	— .0010
Sulphate of potash, 90 per cent (K_2SO_4 c. p. + impurities):						
G. E. Patrick, solution No. 1	.3284	[5].9214	....	.3300	+ .0016	+ .0009
	.1642	[5].4532	....	.1629	— .0013	— .0007
G. E. Patrick, solution No. 2[7]	.3284	[5].9095	....	.3258	— .0026	— .0014
	.3284	[5].9132	....	.3271	— .0013	— .0007
	.3284	[5].9145	....	.3276	— .0008	— .0004
	.3284	[5].9141	....	.3274	— .0010	— .0005
	.3284	[5].9217	....	[6].3301	+ .0017	+ .0009
	.3284	[5].9149	....	.3277	— .0007	— .0004
	.3284	[5].9142	....	.3274	— .0010	— .0005
A. M. Peter	.3284	.9149	.0017	.3271	— .0013	— .0007
F. B. Bomberger	.3284	.9193	.0063	.3270	— .0014	— .0008
	.3284	.9208	....	.3266	— .0018	— .0010
	.3284	.9211	....	.3277	— .0007	— .0004
A. W. Blair	.3284	.9715	.0088	.3448	+ .0164	+ .0089
	.3284	.9706	....	.3445	+ .0161	+ .0087
	.3284	[8].9209	[8].0083	[8].3270	— .0014	— .0008
	.3284	[8].9156	[8].0076	[8].3251	— .0033	— .0018
	.3284	[8].9170	....	[8].3256	— .0028	— .0015
F. S. Shiver	.3284	.9251	.0031	.3303	+ .0019	+ .0010
	.3284	.9245	....	.3300	+ .0016	+ .0009
C. H. Jones	.3284	.9165	.0030	.3272	— .0012	— .0006
	.3284	.9240	....	.3299	+ .0015	+ .0008
	.3284	.9165	....	.3272	— .0012	— .0006
	.3284	.9190	....	.3281	— .0003	— .0002
Sulphate of potash and magnesia (K_2SO_4 c. p. + impurities):						
G. E. Patrick	.1856	[5].5132	....	.1832	— .0024	— .0013
	.1856	[5].5145	....	.1837	— .0019	— .0010
	.1856	[5].5144	....	.1836	— .0020	— .0011
	.1856	[5].5148	....	.1838	— .0018	— .0010

[1] Subsequent washing of K_2PtCl_6 with ammonium chlorid solution and alcohol gave 0.9061 g. = 0.3219 g. K_2SO_4.

[2] Subsequent washing of K_2PtCl_6 with ammonium chlorid solution and alcohol gave 0.9041 g. = 0.3212 g. K_2SO_4.

[3] Subsequent washing of K_2PtCl_6 with ammonium chlorid solution and alcohol gave 0.9061 g. = 0.3219 g. K_2SO_4.

[4] K_2PtCl_6 washed with ammonium chlorid solution.

[5] Corrected with blanks on reagents.

[6] Subsequent washing of K_2PtCl_6 with ammonium chlorid solution and alcohol gave 0.9157 g. = 0.3281 g. K_2SO_4.

[7] The barium chlorid was added largely in the dry state in preparing solution No. 2.

[8] K_2PtCl_6 washed with ammonium chlorid solution and alcohol.

TABLE II.—*Determination of potassium sulphate by the Stassfurt method*—Continued.

[Old factors.]

Substances and analysts.	K_2SO_4 taken.	K_2PtCl_6 total found.	K_2PtCl_6 from reagents.	K_2SO_4 found.	K_2SO_4 error.	K_2O error.
Sulphate of potash and magnesia (K_2SO_4 c. p. + impurities)—Cont'd.	*Gram.*	*Gram.*	*Gram.*	*Gram.*	*Gram.*	*Gram.*
A. M. Peter	0.1856	0.5112	0.0017	0.1819	—0.0037	—0.0020
	.1856	.5127	....	.1824	— .0032	— .0017
F. B. Bomberger	.1856	.5215	.0053	.1843	— .0013	— .0007
	.1856	.5220	....	.1845	— .0011	— .0006
	.1856	.5214	....	.1842	— .0014	— .0008
A. W. Blair	.1856	.5467	.0064	.1929	+ .0073	+ .0039
	.1856	.5464	....	.1928	+ .0072	+ .0039
	.1856	[1].5220	[1].0088	[1].1837	— .0019	— .0010
	.1856	[1].5203	[1].0059	[1].1831	— .0025	— .0014
	.1856	[1].5147	....	[1].1811	— .0045	— .0024
F. S. Shiver	.1856	.5239	.0021	.1863	+ .0007	+ .0004
	.1856	.5261	....	.1871	+ .0015	+ .0008
C. H. Jones	.1856	.5185	.0025	.1842	— .0014	— .0008
	.1856	.5170	....	.1837	— .0019	— .0010
	.1856	.5195	....	.1846	— .0010	— .0005
	.1856	.5190	....	.1844	— .0012	— .0006
Kainit (K_2SO_4 c. p. + impurities):						
G. E. Patrick, solution No. 1	.1000	[2].2784	....	.0994	— .0006	.0003
	.1000	[2].3080	....	[3].1099	+ .0099	+ .0054
G. E. Patrick, solution No. 2	.1000	[2].2784	....	.0994	— .0006	— .0003
	.1000	[2].2797	....	.0998	— .0002	— .0001
	.1000	[2].2819	....	.1006	+ .0006	+ .0003
	.1000	[2].2807	....	.1002	+ .0002	+ .0001
	.1000	[2].2812	....	.1004	+ .0004	+ .0002
	.1000	[2].2813	....	.1004	+ .0004	+ .0002
A. M. Peter	.1000	.2807	.0009	.0999	— .0001	— .0001
F. B. Bomberger	.1000	.2858	.0074	.0994	— .0006	— .0003
	.1000	.2856	....	.0903	— .0007	— .0004
	.1000	.2860	....	.0995	— .0005	— .0003
A. W. Blair	.1000	[4].3883	.0052	[4].1370	+ .0370	+ .0200
	.1000	[5].3987	.0039	[5].1407	+ .0407	+ .0220
	.1000	[6].3830	....	[6].1351	+ .0351	+ .0190
	.1000	[7].3996	....	[7].1410	+ .0410	+ .0221
B. L. Hartwell	.1011	.2846	.0077	.0988	— .0023	— .0012
	.1011	.2854	.0080	.0991	— .0020	— .0011
F. S. Shiver	.1000	.2832	.0023	.1003	+ .0003	+ .0002
	.1000	.2849	....	.1009	+ .0009	+ .0005
C. H. Jones	.1000	.2815	.0025	.0996	— .0004	— .0002
	.1000	.2803	....	.0992	— .0008	— .0004
	.1000	.2811	....	.0995	— .0005	— .0003
	.1000	.2810	....	.0994	— .0006	— .0003

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[1] K_2PtCl_6 washed with ammonium chlorid solution and alcohol.

[2] Corrected with blanks on reagents, 24.5 and 22 cc $BaCl_2$ solution used instead of 20 cc required.

[3] Subsequent washing of K_2PtCl_6 with ammonium acetate solution and alcohol gave 0.3052 g. - 0.1090 g. K_2So_4.

[4] Subsequent washing of K_2PtCl_6 with ammonium chlorid solution and alcohol gave 0.2778 g.—0.0975 g. K_2So_4.

[5] Subsequent washing of K_2PtCl_6 with ammonium chlorid solution and alcohol gave 0.2765 g.- 0.0971 g. K_2So_4.

[6] Subsequent washing of K_2PtCl_6 with ammonium chlorid solution and alcohol gave 0.2792 g. 0.0981 g. K_2So_4.

[7] Subsequent washing of K_2PtCl_6 with ammonium chlorid solution and alcohol gave 0.2746 g.=0.0964 g. K_2So_4.

NOTES BY THE ANALYSTS.

G. E. Patrick.—The manipulations were found somewhat troublesome, and it seems evident that this method, as it relates to sulphates, requires considerable practice to insure success. Quite a large source of error is evident in the volume of the barium sulphate. It seems to me that a correction should be made for this.

C. H. Jones.—My results by the Stassfurt method surprised me, particularly as regards their uniformity. The precipitation of the SO_3 was not so troublesome as I anticipated, although I practiced for half a day on a commercial article before taking up the official samples. In the washing of the K_2PtCl_6 I was very careful to wash by decantation, and the precipitate was in no case put on the felt until the alcohol wash, after a thorough mixing with the platinum salt, was practically colorless. This method of procedure took considerably more time than that employed in the Lindo Gladding method, especially in the case of kainit.

A. M. Peter.—In making these determinations the instructions were closely followed, and the only departure from them was in weighing the K_2PtCl_6 on Gooch filters, washing out with hot water, and drying and weighing the Gooch again, thus eliminating any error from the presence of insoluble particles in the K_2PtCl_6. This is the practice in this laboratory, but instead of Gooch crucibles we prefer a small glass tube like a small carbon tube. Into these tubes we put a plug of glass wool and then pour on the asbestos pulp. The asbestos felt is less easily disturbed in these tubes than in Gooch crucibles, and they may be washed thoroughly with less alcohol.

A. W. Blair.—With the sulphate of potash I found some difficulty in being able to tell just when all the SO_3 was precipitated. I also found my weights entirely too high, and suspecting that the 96 per cent alcohol failed to wash out something, I used in addition the Gladding wash and 80 per cent alcohol. As you will see from my report, that made a difference.

On testing the filtrate from the Gladding wash, I found $CaSO_4$, which confirmed my suspicions.

I used from 5 to 20 cc $PtCl_4$ solution, which will account in part for the large amount of K_2PtCl_6 in reagents.

F. S. Shiver.—I am inclined to the opinion that the method gives high results. The factors used by the syndicate, which are practically our old factors, give results nearer theory than the new factors give.

F. B. Bomberger.—The instructions were closely followed in this work, except that the K_2PtCl_6, after weighing, was dissolved from the crucible with water and the latter ignited and reweighed.

The methods as submitted are not nearly so rapid as the Lindo-Gladding method, and from my experience not nearly so satisfactory.

COMMENTS BY THE REFEREE.

The method as applied to muriate of potash appears to be quite accurate, the KCl found being in some cases slightly more than was taken, in other cases slightly less. The higher results may be explained as due to impurities in the potassium platinichlorid, since, according to this method, the solution of the salt is evaporated directly with platinum solution and no attempt is made to purify the double salt. The use of the old factor compensates in a measure for such an error. The weight of KCl, which would have been obtained by the new factor, may be readily found (except in a few instances where considerably more than 0.25 gram of the salt was employed) by adding 0.0011 gram to the weights given in the table.

The results obtained in determinations of potassium sulphate in commercial sulphate of potash, sulphate of potash and magnesia, and kainit, as reported by all the analysts with the exception of Mr. Blair, are, as a rule, quite close to theory. Mr. Shiver's results invariably show a slight plus error, which would only be exaggerated by the use of the new factor, but results by Messrs. Peter, Bomberger, and Jones, in the case of all three salts, and by Mr. Patrick in the case of sulphate of potash and sulphate of potash and magnesia, are nearer theory when calculated by the new conversion factor.

The weights of potassium sulphate found in sulphate of potash, sulphate of potash and magnesia, and kainit, as given in the table, may be readily converted into the corresponding results by the new factor by adding, respectively, 0.0016, 0.0009, and 0.0005 gram K_2SO_4.

We should not draw hasty conclusions from the results reported, as most of the analysts tried the method for the first time, and it usually requires considerable experience with a new method before the details are thoroughly mastered. This point was brought out clearly last year. Although the results of eight American chemists established the accuracy of the Lindo-Gladding method as applied to potash salts, the Stassfurt chemists, who were not accustomed to the process, reported widely discrepant results by this method.

(2) The "Optional" Method, Acidulating with Hydrochloric Acid before Precipitating the Sulphuric Acid.

The work of the association during the years 1894 and 1895 showed that in the analysis by the "optional" method of materials rich in sulphates, serious losses of potash were sustained through occlusion. With the view of avoiding this source of error, it was suggested that the barium sulphate be precipitated in an acid solution as carried out by the Stassfurt chemists. This modification of the method has been investigated during the present year by Mr. Jones.

Portions of pure potash salts were weighed out in quantities representing 0.5 gram of the four Stassfurt salts and corresponding amounts of solutions of "impurities" were added. The solution was acidified with 1 cc of concentrated HCl and the barium sulphate precipitated, as directed by the Stassfurt method. The analysis was completed as directed for the "optional" method.

Mr. Jones's results, which follow, indicate that the proposed modification has little if any advantage over the official method.

Results by modified method.

Materials.	Muriate of potash (KCl + "impurities").		Sulphate of potash 90 per cent (K_2SO_4 + "impurities").		Sulphate of potash and magnesia (K_2SO_4 + "impurities").	Kainit (K_2SO_4 + "impurities").
	Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
KCl or K_2SO_4 taken	0.4186	0.4191	0.4600	0.4600	0.2610	0.1410
Total K_2PtCl_6 found	1.3729	1.3725	1.2825	1.2800	.7296	.3960
K_2PtCl_6 from reagents and impurities	.0085	.0085	.0090	.0090	.0080	.0053
K_2PtCl_6 corrected	1.3644	1.3640	1.2735	1.2710	.7216	.3907
KCl or K_2SO_4 found (new factors)	.4187	.4186	.4568	.4559	.2588	.1401
Error (KCl or K_2SO_4)	+ .0001	— .0005	— .0032	— .0041	— .0022	— .0009

(3) The Determination of Potash by the Lindo-Gladding Method, Evaporating Directly with Platinum Solution, without Previous Removal of Lime.

According to the original method, as described by Gladding in 1885[1] and adopted the following year by this association, the determination of potash in kainit was made by direct evaporation of a solution of the salt with platinum chlorid, the foreign salts which contaminate the potassium platinichlorid being removed by ammonium chlorid solution.

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[1] United States Department of Agriculture, Division of Chemistry, Bul. 7, p. 41.

At the convention held in 1891 it was contended that the treatment with ammonium chlorid solution was not sufficient to remove calcium sulphate, and although the subject had not been submitted to the members for investigation, it was voted[1] to adopt the present official method, which depends on the precipitation of the lime with ammonium oxalate and the removal of ammonium salts by evaporation and ignition before evaporation with platinum solution.

In 1894 De Roode[2] stated that the direct evaporation method was the most satisfactory, and to support this view gave results by this method and the official Lindo-Gladding, the "optional," and the Stassfurt methods.

Vogel and Hafecke,[3] who apparently were not familiar with the original Lindo-Gladding method, refer to De Roode's article and state that the direct evaporation process, as applied to kainit, may be regarded as a combination of the Lindo-Gladding and the shorter Fresenius methods.

Last year four chemists made determinations by direct evaporation on mixtures of pure potassium sulphate and kainit "impurities." The K_2SO_4 found, as calculated by the new factor, in no case differed more than 0.0004 gram from that taken; or, in other words, the maximum error was equivalent to but 0.08 per cent K_2O in kainit. The errors by the official Lindo-Gladding method were in a number of cases considerably greater.

The following results reported by Messrs. Peter and Hartwell were obtained on K_2SO_4 c. p., mixed with kainit "impurities," and furnish further evidence that removal of lime by precipitation is unnecessary:

1. Comparison of methods.

Materials.	A. M. Peter.	B. L. Hartwell.			
	Direct evaporation.	Official method.		Direct evaporation.	
	Gram.	*Gram.*	*Gram.*	*Gram.*	*Gram.*
K_2SO_4 taken	0.1400	0.1569	0.1657	0.1553	0.1547
Total K_2PtCl_6 found	.3914	.4439	.4711	.4356	.4296
K_2PtCl_6 from impurities and reagents	....	.0011	.0008	....	....
K_2PtCl_6 corrected	.3914	.4430	.4702	.4356	.4296
K_2SO_4 found (factor 0.3587)	.1404	.1589	.1687	.1562	.1541
Error, K_2SO_4	+.0004	+.0020	+.0030	+.0009	—.0006

Although the results on artificial kainit point to the accuracy of the direct evaporation process, it seemed desirable to make comparative determinations by this and the official method on a variety of samples of commercial kainit.

Mr. Peter found in a sample of kainit from the Kentucky market the same percentage of K_2O (13.35) by the two methods.

The percentage of potash in 10 samples collected in South Carolina was determined by Mr. Shiver, with the following results:

2. Comparison of methods.

Methods.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.	No. 8.	No. 9.	No. 10.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Official method	12.87	12.89	12.50	12.57	12.68	12.23	10.27	12.31	12.24	12.32
Direct evaporation	12.74	12.77	12.47	12.46	12.64	12.29	10.30	12.24	12.18	12.42

In the analysis of a Vermont sample Mr. Jones found 11.97 and 11.98 per cent K_2O by the official method and 11.94 and 12.02 per cent by direct evaporation.

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[1] United States Department of Agriculture, Division of Chemistry, Bull. **31**, p. 158.

[2] J. Amer. Chem. Soc., **17**, 85.

[3] Land. Versuchs-Stationen, **47**, 117.

The results of the past two years, both on the mixtures of pure K_2SO_4 with kainit "impurities" and on commercial kainit, demonstrate that the direct evaporation process is fully as reliable as the official method. As it is in addition much shorter, and much more easily carried out, there is abundant reason for returning to this, the original method, which, if the two methods had been thoroughly investigated six years ago, would probably never have been abandoned.

(4) QUANTITIES OF PLATINUM SOLUTION NECESSARY FOR DETERMINATION IN GERMAN POTASH SALTS.

The quantities of platinum solution which are directed for use in the determination of potash in the Stassfurt salts by the Lindo-Gladding method (10 cc for 0.5 gram of muriate of potash and 15 cc for 0.5 gram of the other salts) are in large excess of what are needed for converting both the potash and the soda into the double salts. Five cc supply an excess of chloroplatinic acid for kainit and sulphate of potash and magnesia, and 6 cc for muriate of potash and high grade sulphate of potash. If a liberal excess be desired, 8 cc are sufficient for all of the four salts.

In 1891 the referee[1] found in a sample of double sulphate of potash 27 per cent K_2O, using 15 cc of platinum solution, and 26.98 per cent, using 8 cc; and in a sample of kainit 9.98 and 9.90 per cent, respectively.

Mr. Jones in the analysis of muriate of potash and sulphate of potash finds 8 cc sufficient in all cases.

Mr. Peter writes as follows:

> In regard to the use of a smaller quantity of platinum chlorid, I will say that it is the practice of this laboratory to use only a slight excess above the amount necessary to combine with the potash. We use a solution of platinum chlorid containing about 20.6 grams platinum to the liter, 1 cc of this being equivalent to 1 per cent of K_2O, on a basis of 1 gram substance taken. We add only 1 or 2 cc more of this solution than there are supposed to be per cents of K_2O in the substance. When the liquid is nearly all evaporated, it is very easy to tell whether enough platinum has been added by removing the beaker from the water bath and allowing it to cool slightly. On inclining the beaker so that the liquid runs away from the precipitate, it is easily seen whether the liquid has the peculiar color of platinum chlorid, and if it have not, but is too light colored, more platinum solution is added. Results are entirely satisfactory and waste of platinum is avoided. Of course, this proceeding is only applicable to the Lindo-Gladding method and where the NH_4Cl wash is used.

It appears that a saving of platinum solution can be readily effected without interfering with the accuracy of the method. This is especially desirable now that the price of the metal is advancing.

Mr. Winton said, in closing his report:

"I am opposed to making any recommendations, but will say I think we ought to return to the direct evaporation process in the analysis of kainit. Every figure we have obtained in the last two years shows that this is a desirable change, and I suggest that it be made. I can hardly recommend that the Stassfurt method be adopted. The results are, many of them, very good indeed, and I think the method thoroughly reliable, but the American people are altogether too active to take up a method of that sort. I can see no advantage in adopting it, unless it prove very much more accurate. Possibly it might be well to investigate it further during the coming year. The method is a good one; the question is whether the association wishes, eventually, to adopt it or not. I will not take the responsibility of recommending that it be adopted, nor will I recommend that the referee for next year be put through the same course of sprouts that I have been.

RECOMMENDATIONS.

"I have made only this one recommendation, that we return to the original method for kainit. I am also tempted to recommend that we stop this extravagance in the use of platinum solution. Possibly the association prefers to investigate that subject another year. I am fully satisfied that small quantities are sufficient, and I think at most of our stations smaller quantities are used. I am loth to make any recommendations on the results of the year. I therefore suggest merely that the subject be submitted for investigation the ensuing year."

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[1] U. S. Dept. Agr., Div. of Chem., Bull. **31**, 149.

Mr. Wiley conveyed to the association an invitation from the Cosmos Club to enjoy the privileges of the club, and on his own behalf invited the members to visit the Department of Agriculture and inspect the chemical laboratories. A resolution of thanks for both invitations was adopted.

The convention adjourned until 2.30 p. m.

TUESDAY—AFTERNOON SESSION.

The **President**. The order of business calls for the presentation of papers on the determination of potash. If none be presented, discussion on topics relating to the determination of potash is in order.

DISCUSSION ON POTASH.

Mr. **Lindsey**. Referring to the Stassfurt method, I would like to ask the referee whether it is possible to use that method on all the multitudinous mixed fertilizers that are analyzed?

Mr. **Winton**. This method is only used for the potash salts.

Mr. **von Herff**. It simply requires previous treatment with sulphuric acid, the same as in the Lindo-Gladding method. I see no reason why it should not be used in all cases.

Mr. **Winton**. How would you get rid of the soluble organic matter?

Mr. **von Herff**. With sulphuric acid, the same as in the Lindo-Gladding method. It has not been tried, so far as I know, but if it work in one it is reasonable to suppose it will in the other cases.

Mr. **Huston**. Is it supposed that it is applicable in those cases where the law specifies that we must handle only potash soluble in water? It will require considerable roundabout work to use the method, as I understand it, if we are to use it in such cases, and many of us are limited to potash actually soluble in water.

Mr. **von Herff**. In what way would that interfere?

Mr. **Huston**. We have a large amount of organic matter soluble in water.

Mr. **von Herff**. What do you do in the Lindo-Gladding method in such cases? I do not see that it would complicate the method at all, except that you know you have a little more organic matter and perhaps use a drop or two more sulphuric acid.

I was not fortunate enough to hear the report read, but I believe the general experience seems to be that the Stassfurt method is somewhat difficult. Against this I may say that the main advantage claimed by the Stassfurt chemists over the Lindo Gladding method is in simplicity of execution. Perhaps with more experience any difficulties that may exist may be overcome. Every chemist must become familiar with a method before he can use it well. It must be remembered that chemists here have long been familiar with the Lindo-Gladding method.

Mr. **Winton.** With regard to results by American chemists using the Stassfurt method, they were quite good, but not quite up to——

Mr. **von Herff** (interrupting). That is a good beginning, I think.

Mr. **Winton.** Very good. But the Stassfurt method certainly has no advantage over the Lindo-Gladding method so far as our results go.

Mr. **von Herff.** If both methods get good results, one would be as good as another. It is an advantage, however, to have one method adopted universally.

The **President.** I think if it comes to be understood on the other side of the water that chemists on this side get as reliable results with the Lindo-Gladding method as they can with the Stassfurt method, that difficulty will be obviated. If that comes to be understood clearly, the point the gentleman has raised will be dissipated without the necessity of educating American fertilizer control chemists in a new method.

Mr. **Lindsey.** It seems to me that a great deal of very careful work has been done this year in comparing these two methods. I think the point should be taken into consideration, as Mr. von Herff states that the Stassfurt method is comparatively new to our chemists, and it certainly does require some experience to get the best results with any method. On the other hand, it would seem to me that so far as they have gone the Stassfurt method does, in their hands, give quite reliable results; but it certainly is in no sense, if I understand their report, superior to the Lindo-Gladding method. The Lindo-Gladding method, it appears, can be worked more quickly than the Stassfurt, and therefore if Mr. von Herff is so desirous that we should all have one method, I think it is the sense of this association that we recommend our friends across the water to adopt the Lindo-Gladding method.

Mr. **von Herff.** When it comes to final action this is a matter of importance, and I would admit both methods, so that in case difficulties arise they can be settled on an equal basis. It is admitted by the association that the method is accurate, and therefore there is no reason to leave it out of consideration entirely. So far as simplicity is concerned, it is strongly claimed by the Stassfurt chemists that it is the quickest possible. They work it in a very short time without difficulty.

Mr. **Winton.** I would like to ask our friend whether, if we adopt the Stassfurt method, the German chemists will return the compliment and adopt the Lindo-Gladding method? Possibly we can meet them halfway.

Mr. **von Herff.** I have no authority to speak for the Stassfurt chemists, and I can say nothing about that. They have no association, so far as I know. There are quite a number of chemists there and they all work this method, but I believe they would be very much pleased to adopt the Lindo-Gladding method if there be any simplicity in it. But they say the other is very much quicker.

Mr. HILLS. Do chemists in Germany, as a rule, use the Stassfurt method?

Mr. VON HERFF. There has been issued a printed circular describing the method in detail, and I think it is used in most of the laboratories.

Mr. HILLS. For mixed fertilizers?

Mr. VON HERFF. They have not so many mixed fertilizers in Germany.

Mr. WINTON. In the matter of the simplicity of the two methods I think the only way we can arrive at a true solution of the problem is by having a competitive trial in some laboratory. But I think our friends the Stassfurt chemists are hardly acquainted with the Lindo-Gladding method as we use it. They recommend for the Stassfurt method weighed filter paper. Now, we gave that up in this country, and use instead the Gooch crucible. In their latest instructions they say the Gooch crucible may be used, but it is very evident that they are not experienced with it, and I do not think they appreciate what a very simple undertaking it is to purify K_2PtCl_6 when collected in a Gooch crucible. I think it must be very much shorter than precipitating with sulphuric acid, as they do.

Mr. JONES. In regard to the question of time in the manipulation of the two methods, I think, that so far as one sample is concerned, the time consumed in the two processes might be about the same, but with a string of a dozen or twenty samples I think the Lindo-Gladding method would beat the other 2 to 1 easily.

Mr. HILLS. I would like to ask Mr. Winton if the German chemists have tried the Lindo-Gladding method except at the one time he mentioned in this morning's talk?

Mr. WINTON. The results are given in full in last year's report. I can not say whether any of them have tried it before, but I should say from the results that they had not. The whole trouble is, I think, that they collected the salt on the weighed paper. I do not think the Lindo-Gladding method works so well when you use weighed filter paper. I do not feel, however, that it has had a fair trial on the other side of the water.

Mr. VON HERFF. I believe the question before this association is practically this: Should it be allowed to use the Stassfurt method or must the Lindo-Gladding method be used? It has been acknowledged that the Stassfurt method is an accurate one and has been used by the parties most interested in potash, therefore I do not see why it should be rejected, nor why it should be said that such and such a method is our official method and no other should be admitted, although the other is admitted to be accurate.

The PRESIDENT. If there be no further discussion, the report is referred to the committee on recommendations.

RECOMMENDATIONS.

The committee on methods of potash analyses made the following recommendations:

1. That the same method be used for determining K_2O in kainit as is now used for sulphate and double sulphates. Adopted.
2. That the referee investigate our present methods for determining K_2O as applied to wood ashes and cotton-hull ashes. Adopted.
3. That the alternate method for determining K_2O is not recommended when K_2O is present in the form of sulphate. Mr. Van Slyke suggested that the word alternate be changed to optional. Adopted.
4. That the referee for 1898 investigate methods for determining chlorin.

Mr. **Bartlett** (chairman of the committee on recommendations). We found in talking the matter over that the association had no official method for determining chlorin; that several different methods were used, and that the subject was worthy of investigation.

The fourth recommendation was adopted.

The chair called for the report of the committee appointed last year to make a reply to the Stassfurt chemists on their strictures on the Lindo-Gladding method. The report was read by Mr. Winton. It was decided to offer the report for publication in the Versuchs-Stationen, the organ of the German experiment stations.[1]

Mr. **Scovell.** Will that report be printed as a part of the proceedings?

The **President.** It is presented as a part of the proceedings, and will be printed in some chemical journal.

Mr. **Van Slyke.** I think we ought to take some official action indicating the approval of the association, and I therefore move that the association approve the report as read.

Seconded and adopted.

Mr. **Bigelow.** In regard to the publication of this matter, I think it was suggested last year that it would be well to have it more widely published than in our bulletin, and I move that the committee be instructed to use their own judgment as to where it shall be published, but have it printed in at least one scientific journal of large circulation.

Seconded and adopted.

Mr. **Winton.** I wish to bring up a reconsideration of the motion passed this morning with regard to potash. It was moved and carried, I believe, that the optional method for the determination of potash be not recommended when the potash exists in the form of sulphate. I move that this be reconsidered. It is my purpose to refer the subject again to the committee.

The motion was seconded and carried.

Mr. Winton then moved that the question be again referred to the committee, which was adopted, and the matter declared to be so referred.

Mr. **Bartlett.** The committee recommends that under the head of optional method for determination of potash, the following be inserted: The Lindo-Gladding method is preferable in the presence of soluble sulphates.

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[1] The paper is published in Chemical News, vol. 77.

Mr. **Wheeler.** I will say that this is merely a signboard hung up before this optional method to show that you can not get good results in the presence of sulphates.

The recommendation was adopted.

Mr. Patterson, on behalf of the committee on order of business, reported that after careful consideration it seemed best to visit the laboratories of the Department of Agriculture on Wednesday afternoon, immediately after the election of officers. Upon motion it was agreed, after some discussion, that the election of officers take place Wednesday afternoon at 2 o'clock, and that immediately thereafter the association adjourn to visit the Department of Agriculture.

Mr. **Wheeler.** Before the matter of phosphoric acid is taken up I would like to call the attention of the association to the movement that is on foot to secure uniform legislation on the subject of fertilizer laws. I would say that a preliminary meeting was called in New Haven at which representatives of a number of States were present, and a committee was appointed to take steps toward securing, if possible, uniform legislation in the different States. This committee met in May in New York, held a conference with a committee of the Eastern Fertilizer Association, and as a result of that meeting recommended that this association and the Association of Agricultural Colleges and Experiment Stations each appoint a committee to take such further steps as may seem desirable. The Association of Agricultural Colleges has a committee, but this association has not. It would seem appropriate that this association should join the other in the effort to secure this end; and I would therefore move that the chairman appoint a committee of five from this association to act with the committee from the other association, and that they be authorized to take such further action as may seem desirable, and report to the association at a later meeting.

Seconded.

Mr. **Wiley.** In supporting this motion, I would like to suggest that, as we have already appointed on that committee by the Association of Agricultural Colleges a number of gentlemen who are also members of this association, the president, in exercising his discretion in this matter, include those gentlemen on our committee, so that in that way they may represent both associations. I think at least three of the committee appointed at Minneapolis are members of this association.

Mr. **Wheeler.** I will say that I bring this matter up now so that those appointed upon this committee may know that we look to have them remain for a committee meeting after the close of our association, because a meeting of the committee of agricultural colleges has been called for Friday morning, and probably everything necessary to be done now can be done in a very short time.

The motion was carried. The chair announced the members of the committee later.

The report on phosphoric acid was read by Dr. McDonnell, state chemist of Maryland.

REPORT ON PHOSPHORIC ACID, IRON AND ALUMINA, AND BASIC SLAG.

By H. B. McDONNELL, *Referee.*

During the latter part of January last the referee sent out a circular letter asking the cooperation of chemists in the work on phosphoric acid, and also on iron and alumina and basic slag, as directed by the association last year. Twenty-three chemists requested samples, which were sent out about March 1. A small reserve of five sets of samples was prepared, as, according to the experience of last year, this number would have been ample. This reserve, however, was soon exhausted, and I was unable to furnish samples to at least three chemists who afterwards applied.

Of the samples sent out No. 1 was the same as No. 1 of last year, having been made up at that time and kept as a reserve supply sealed in the bottles as sent out. The nature of the other samples is sufficiently indicated in the tables and instructions, except No. 8, which is described on page 56.

The results reported by the various analysts are given in the following tables: Table I gives the average of results reported on phosphoric acid; Table II, the detailed results as reported, except those by the "yellow method," which are given in Table III. Table IV gives the results on iron and aluminum, and Table V the results on basic slag.

With each set of samples was sent the following:

DIRECTIONS FOR WORK ON PHOSPHORIC ACID.

Determine total phosphoric acid in samples 1 to 6 inclusive, by—

A. The official gravimetric method.

B. The modified volumetric method. This method, which is recommended by the referee, has given excellent results in his laboratory in thousands of comparisons with the gravimetric method on "insolubles." It is as follows:

To an aliquot portion of the solution, prepared according to one of the official methods, preferably A_5, is added NH_4OH in excess, then HNO_3 in excess, then the regular molybdate solution (which should be filtered if necessary) in excess. Warm on the water bath to about 50° C. for twenty or thirty minutes, with occasional stirring; filter, wash with water at ordinary temperature until filtrate fails to show acidity when tested with litmus paper. Transfer the filter and contents to a beaker, add 20 to 40 cc of water and standard alkali sufficient to dissolve, stirring well; titrate excess of alkali with standard sulphuric or nitric acid, using phenolphthalein as indicator.

Nitric acid wash for yellow precipitate is not necessary, and nitrate solutions should be avoided, because molybdic acid is insoluble therein.

Overheating of the yellow precipitate is to be avoided, as it may cause a granular precipitate of molybdic acid which is difficult to wash out.

Good results are also obtained by heating the solution, after the addition of the molybdate, to 50° C. and allowing it to stand over night at ordinary temperature.

C. The volumetric method as given in Bulletin 46 and Circular 2, Chemical Division, United States Department of Agriculture.

D. Gladding's "yellow method" sent herewith. Mr. Gladding now recommends two final washings with alcohol in order to facilitate the drying, which is done in a glycerol bath at 105° C. (J. Am. Chem. Soc., Jan., '96, p. 23.)

METHODS FOR THE DETERMINATION OF "AVAILABLE" PHOSPHORIC ACID IN BASIC SLAG.

(Outline suggested by Mr. Wiley):

(*a*) Solubility in official ammonium citrate solution.
(*b*) Solubility in Wagner's ammonium citrate solution.
(*c*) Solubility in 1 per cent ammonium citrate solution.
(*d*) Determination of the fineness of sample.
(*e*) Determination of the per cent of sample removed by magnet.

Make determinations as follows on samples Nos. 6 and 7; the former is American, the latter European slag:

1. (*a*) Determine "available" by the regular official method.

(*b*) Determine the "available" by the regular official method, except to treat the substance with the citrate for one hour.

2. *Wagner's method.*—Five grams of the slag meal, without further grinding or sifting, are put into a half-liter flask which is filled to the mark with dilute ammonium citrate solution, the temperature of which is 17½° C. The flask is closed by means of a rubber stopper and immediately put into a revolving agitating apparatus for thirty minutes, the revolutions being made at the rate of 30 to 40 per minute, and filtered at once.

Fifty cubic centimeters of the filtrate are mixed with 100 cc of molybdate solution and heated on a water bath at 80° to 90° C. for from ten to fifteen minutes; the mixture is removed from the bath, cooled to the temperature of the room and the process continued by the usual gravimetric method.

Wagner's concentrated ammonium citrate solution contains in 1 liter 150 grams of crystallized citric acid and 23 grams of ammoniacal nitrogen. The latter is to be determined accurately by analysis by distilling off the ammonia from a measured volume of the solution (after making the solution up with approximately the proper amount of ammonia to exactly eight or nine tenths of the intended volume). The determination is made as in the Gunning method, omitting the digestion. The solution is now made up with ammonia of such strength that the total nitrogen per liter is 23 grams.

For use, two volumes of this solution are diluted with three volumes of water.

3. Treat 1 gram slag meal in an 8-ounce (250 cc) Erlenmeyer flask with 100 cc of 1 per cent citric acid solution at approximately 20° C. for one hour, shaking moderately every ten minutes. Filter through a dry filter and determine P_2O_5 in 40 or 50 cc of the filtrate by the molybdate method.

Try also the effect of treating the slag as above (under 3) for two hours instead of one hour.

4. Determine fineness on 10 grams of sample by using: (*a*) Brass sieve with circular holes ½ mm in diameter. (*b*) Sieve of bolting cloth having 4 meshes to the mm. (*c*) Sieve of bolting cloth having 10 meshes to the mm, making four separations. (Note.—After these directions were given it was found that bolting cloth with 10 meshes to the mm could not be obtained and that with 5 meshes to the mm was used instead; the latter is approximately one-tenth mm between the meshes.)

5. Determine the amount of sample removed by a magnet. Use 1 gram for the determination, spread in a thin layer on glazed paper.

METHODS FOR THE DETERMINATION OF IRON AND ALUMINA IN PHOSPHATES.

Determine iron and alumina in samples 1, 4, 5, 6, and 8 by the methods given below. Sample No. 8 is composed of pure chemicals and its composition is accurately known.

1. *Acetate method.*—Dissolve 2 to 2½ grams of the phosphate in 30 cc HCl and 10 cc HNO_3 (all iron must be in the ferric state), cool, make up to 250 cc, and take 50 cc for the determination. Add 2 drops of 1 per cent methyl orange and ammonia until alkaline. Dissolve the precipitate in very slight excess of HCl, dilute to about 300 cc, add 25 cc 20 per cent ammonium acetate solution for one hour and filter. Dissolve the precipitate in hot dilute HCl, and precipitate as before twice more, making three precipitations in all. Wash precipitates with hot water. Incinerate the precipitate in a platinum crucible, cool, add about 2 to 5 grams Na_2CO_3, or Na_2CO_3 and K_2CO_3, fuse gently from fifteen to twenty minutes, dissolve the fusion in hot water, filter and wash. Acidify the filtrate with HCl, boil off CO_2, dilute to 300 cc, and precipitate with ammonium acetate as above. Filter, wash the precipitate practically free of chlorids, ignite and weigh as $AlPO_4$, which multiplied by 0.418 equals Al_2O_3.

Dissolve the Fe_2O_3 on the filter in hot dilute HCl, precipitate with ammonia, wash free of chlorids and weigh as Fe_2O_3.

Before precipitating the iron and aluminum phosphates as above, it is probably desirable to add a little ammonium or sodium phosphate.

2. *Thiosulphate method.*—Dissolve 2 to 2½ grams of the material in 30 cc HCl in a 250 cc flask, cool, make up to mark, take 50 cc and determine iron by permanganate (Margerite's method, Fresenius Quant. Anal., p. 267, edition 1881). The HCl may be practically all removed by boiling with the H_2SO_4.

To 50 cc of the original solution add NH_4OH in slight excess, and then HCl until faintly acid. Now add 1 cc of a 1 per cent solution of KCNS, warm to about 65° C., and reduce the iron with ammonium thiosulphate, using a 2 per cent solution. (Sodium thiosulphate may be used instead.) This should be done very slowly and there should be no odor of SO_2 until after the color has entirely disappeared; the solution must remain perfectly clear. Dilute to about 300 cc, add 25 cc 50 per cent ammonium or sodium thiosulphate solution, bring to a boil and continue to boil for thirty minutes, remove from flame, let settle for five or ten minutes and filter, washing out the beaker thoroughly and twice on the filter with water at 65° C. Dissolve the $AlPO_4$ on the filter back into the beaker in which the precipitation was made, with hot 25 per cent KOH free from Al_2O_3, washing finally several times with hot water. Make faintly acid with HCl and precipitate with ammonium thiosulphate, boiling a half hour as before; filter on a Gooch crucible, wash with warm water till free of chlorids, ignite and weigh. Multiply by 0.418 for Al_2O_3.

3. *G. Glaser's method.*—Remove metallic iron by magnet. Dissolve 2 grams in aqua regia, dilute to 250 cc and use 50 cc for analysis. Add NH_4OH until barely acid to methyl orange; add ammonium acetate (containing free acetic acid) until color turns quite yellow; heat to 70° C., let settle well; incinerate precipitate after washing with warm water, in a platinum crucible at a low heat; let cool, mix with about 2 grams $KNaCO_3$, and fuse for fifteen minutes at a gentle heat. Dissolve fusion in hot water and filter over ashless filter. Filtrate contains all Al_2O_3 and most P_2O_5. Residue on filter contains Fe_2O_3, some P_2O_5 and possibly some $CaCO_3$. Filtrate is acidified with HCl, CO_2 boiled off and $AlPO_4$ precipitated as before. After washing precipitate redissolve in warm HCl, add some pure P_2O_5 solution or $(NH_4)_2HPO_4$ (but no salt of fixed alkali), repeat precipitation as before, wash well with tepid water, incinerate and weigh as $AlPO_4$. Weight multiplied by 0.42 equals Al_2O_3. Iron residue on filter is dissolved in hot dilute HCl and washed into beaker; precipitate by NH_4OH, add sufficient c. p. citric acid to obtain a clear alkaline solution. Now ammonium sulphide is added in excess. Stir well for a short time, let settle (usually clear in ten minutes) filter over ashless filter, wash well with dilute ammonium sulphid to remove last traces of citric acid, dissolve black precipitate in dilute HCl, oxidize by HNO_3, finally precipitate with NH_4OH, wash, incinerate, and weigh as Fe_2O_3.

Where methods employed differ from directions given please give details.

It is desired that all results be reported by July 1, and in no case later than one month before the next meeting of the association, in order to give the referee ample time to tabulate the work.

H. B. McDonnell, *Referee.*

TABLE I.—*Average results showing content of phosphorus obtained by analysts of phosphoric acid samples.*

Analysts.	1. S. C. rock.			2. Bone.			3. Cotton-seed meal.		
	Grav.	Mod. vol.	Vol.	Grav.	Mod. vol.	Vol.	Grav.	Mod. vol.	Vol.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Stillwell and Gladding	28.16	28.20	....	22.72	22.75	....	2.56	2.59	....
J. Thompson, S. C	28.09	28.20	....	22.71	22.83	....	2.64	2.62	....
C. C. McDonnell, S. C	27.99	28.03	....	22.64	22.67	....	2.59	2.61	....
F. S. Shiver, S. C	27.96	28.16	....	22.60	22.58	....	2.62	2.58	....
M. A. Scovell, Ky	....	(1)	28.21	....	[2]23.62	23.29	....	2.63	2.69
A. M. Peter, Ky	28.20	27.85	28.37	22.80	22.65	....	2.62	2.61	....
H. E. Curtis, Ky	28.25	28.72	28.05	22.81	23.46	23.15	2.58	2.60	2.53
Ora K. Knight, Me	28.08	27.46	....	23.22	22.70	....	2.65	2.70	....
C. B. Williams, N. C	27.37	27.51	27.80	22.36	22.34	22.78	2.57	2.61	2.62
C. D. Harris, N. C	27.63	....	....	22.39	....	....	2.54	....	....
E. G. Runyan, D. C	28.21	27.75	27.60	22.99	22.85	22.60	2.56	2.52	2.54
C. H. Jones, Vt	28.18	28.25	....	23.08	23.05	....	2.65	2.49	....
B. O. White, Vt	28.22	....	....	23.12	....	....	2.56	....	....
W. L. Mitchell, Conn	28.13	28.29	....	22.52	22.64	....	2.53	2.55	....
W. H. Andrews, N. Y	27.70	28.25	....	22.78	22.86	....	2.57	2.68	....
A. D. Cook, N. Y	27.59	27.51	....	23.07	23.06	....	2.50	2.56	....
C. W. Norris, Pa	28.31	[2]29.19	....	22.86	[2]24.12	....	2.62	2.78	....
F. P. Veitch, Md	28.01	28.02	....	22.61	22.99	23.17	2.52	2.67	....
W. Skinner, Md	28.02	27.92	....	23.04	23.02	....	2.66	2.68	....
Difference between highest and lowest	.94	1.78	.77	.76	1.78	.69	.16	.29	.16
Greatest difference from average	.63	1.18	.41	.43	1.24	.29	.07	.13	.06
Number averaged	18	15	5	18	15	5	18	17	4
Average	28.00	28.01	28.01	22.79	22.83	23.00	2.59	2.62	2.50

[1] Too discordant for average.

[2] Omitted from average.

TABLE I.—*Average results showing content of phosphorus, etc.*—Continued.

Analysts.	4. Fla. phosphate.			5. Ala. phosphate.			6. Pottstown slag.		
	Grav.	Mod. vol.	Vol.	Grav.	Mod. vol.	Vol.	Grav.	Mod. vol.	Vol.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Stillwell and Gladding	30.16	30.10	....	....	42.00	....	16.70	16.60	....
J. Thompson, S. C	30.15	30.33	....	42.23	42.37	....	16.28	16.27	....
C. C. McDonnell, S. C	30.17	30.18	....	42.24	42.74	....	16.26	16.34	....
F. S. Shiver, S. C	30.16	30.25	....	42.35	42.10	....	15.91	16.03	....
M. A. Scovell, Ky	....	[1]31.62	30.70	....	(2)	43.15	....	16.61	....
A. M. Peter, Ky	30.04	30.15	30.60	42.15	42.50	43	16.16	16.75	16.24
H. E. Curtis, Ky	30.10	30.92	30.45	43.14	43.92	43.40	16.51	16.48	16.05
Ora K. Knight, Me	30.04	29.92	....	42.53	42.30	....	15.97	15.47	....
C. B. Williams, N. C	29.27	29.14	29.90	41.40	41.37	41.59	15.69	15.70	16.26
C. D. Harris, N. C	29.81	....	....	41.23	....	....	15.67	....	....
E. G. Runyan, D. C	30.22	30.05	29.90	42.26	42.23	41.90	16.08	15.75	15.80
C. H. Jones, Vt	30.30	30.28	....	42.56	42.54	....	16.40	16.48	....
B. O. White, Vt	30.40	....	....	42.64	....	....	16.40	....	....
W. L. Mitchell, Conn	30.58	30.89	....	42.91	42.62	....	16.30	16.14	....
W. H. Andrews, N. Y	30.21	30.64	....	42.58	42.69	....	16.18	16.11	....
A. D. Cook, N. Y	30.36	30.47	....	42.36	42.41	....	16.29	16.08	....
C. W. Norris, Pa	30.24	[1]31.45	....	42.84	[1]44.26	....	16.69	[1]16.89	....
F. P. Veitch, Md	29.97	29.92	....	42.62	42.23	....	16.39	16.56	....
W. Skinner, Md	30.13	30.06	....	42.37	41.97	....	16.63	16.54	....
Difference between highest and lowest	1.31	2.48	.80	1.91	2.89	1.81	1.03	1.42	.46
Greatest difference from average	.48	1.14	.39	.77	1.03	.79	.45	.66	.17
Number averaged	18	15	5	17	15	5	18	16	4
Average	30.10	30.19	30.31	42.37	42.40	42.61	16.25	16.23	16.09

[1] Omitted from average.

[2] Too discordant for average.

TABLE II.—*Detailed results on phosphoric acid as reported by analysts.*

Analysts.	1. S. C. rock.			2. Bone.			3. Cotton-seed meal.			(1)
	Grav.	Mod. vol.	Vol.	Grav.	Mod. vol.	Vol.	Grav.	Mod. vol.	Vol.	
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
Stillwell and Gladding, N. Y	28.16	28.20	....	22.72	22.75	....	2.56	2.59	....	
John Thompson, S. C	28.09	28.20	....	22.71	22.83	....	2.64	2.62	....	A_5
C. C. McDonnell, S. C	27.99	28.03	....	22.64	22.67	....	2.59	2.61	....	
	28.05	....	....	22.68	....	....	2.59	....	....	(2)
F. S. Shiver, S. C	27.96	28.16	....	22.60	22.58	....	2.62	2.58	....	(3)
M. A. Scovell, Ky	....	[4]28.32	[4]28.40	....	23.62	23.40	....	2.64	2.70	A_4
	....	[4]29.61	[4]28.15	....	....	23.60	....	2.62	2.68	
	....	....	[4]28.15	....	....	22.85	....	....	....	
	....	....	[4]28.10	....	....	22.95	....	....	....	
	....	....	[4]28.25	....	....	23.67	....	....	....	
	....	....	[4]27.90	....	....	[5]21.75	....	....	....	
A. M. Peter, Ky	[5]28.20	[5]27.85	[6]28.10	[7]22.80	[7]22.65	....	[7a]2.62	[7a]2.61	....	

[1] See Bulletin No. 46, Division of Chemistry, page 12.

[2] Dissolved in H_2SO_4 and KNO_3.

[3] Volumetrics stood over night.

[4] Dissolved by A_7.

[5] Dissolved by A_5.

[6] HA and HNO_3.

[7] HNO_3.

[7a] $Mg(NO_3)_2$.

TABLE II.—*Detailed results on phosphoric acid as reported by analysts*—Continued.

Analysts.	1. S. C. rock.			2. Bone.			3. Cotton-seed meal.			(1)
	Grav.	Mod. vol.	Vol.	Grav.	Mod. vol.	Vol.	Grav.	Mod. vol.	Vol.	
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
A. M. Peter, Ky		[2] 29.20	[3] 28.40		[2] 23.30					
			[3] 28.60							
H. E. Curtis, Ky	28.25	28.72	28.05	22.80	23.46	23.15	2.58	2.60	2.53	(4)
	28.25			22.82			2.57			
Ora K. Knight, Me	[5] 28.08	27.46		[5] 23.22	22.72		[5] 2.65	2.62		
	[6] 28.15	[7] 27.38		[6] 23.06	22.68		[6] 2.56	2.79		
	[8] 28.18			[8] 23.30	[7] 22.68		[8] 2.72			
C. B. Williams, N. C.	27.34	27.51	27.75	22.32	22.29	22.73	2.58	2.57	2.55	
	27.40	27.50	27.85	22.40	22.88	22.83	2.55	2.64	2.68	
C. D. Harris, N. C	27.67			22.29			2.52			
	27.58			22.48			2.56			
E. G. Runyan, D. C.	28.21	27.75	27.60	22.99	22.85	22.60	2.56	2.52	2.54	
W. L. Mitchell, Conn.	28.12	28.23		22.43	22.68		2.51	2.53		(9)
	28.00	28.36		22.61	22.61		2.56	2.57		
	28.20									
	28.20									
C. H. Jones, Vt	[10] 28.18	[11] 28.30		[10] 23.08	[11] 23.00		[10] 2.65	[12] 2.49		
		[13] 28.25			[13] 23.10					
		[12] 28.20			[12] 23.05					
B. O. White, Vt	[10] 28.22			[10] 23.12			[10] 2.56			
W. H. Andrews, N. Y.	27.60	28.20	200 cc H_2O	22.80	22.85		2.62	2.69		
	27.74	28.22		22.76	22.86		2.55	2.68		
	27.75	28.20			22.87		2.55	2.68		
		28.30	300 cc H_2O							
		28.35								
A. D. Cook, N. Y	27.50	27.41		23.08	23.08		2.50	2.54		
	27.68	27.60		23.06	23.04		2.50	2.58		
C. W. Norris, Pa	28.33	29.30	28.46	22.76	23.83	23.64	2.60	2.75	2.74	
	28.47	29.28	28.95	23.02	24.41	23.40	2.60	2.81	2.79	
	28.29	28.99	28.85	22.74		24.26	2.69		2.75	
	28.14			22.75			2.63			
				23.02						
F. P. Veitch, Md	28.01	27.90		22.60	22.90	23.17	2.57	2.68		
	28.01	27.95		22.68	22.85		2.46	2.65		
		28.10		22.68	[14] 23.07					
		[14] 28.00		22.89	[14] 23.15					
		[14] 28.15		22.52	[14] 23.00					
W. Skinner, Md	27.99	27.88		23.03	23.01		2.62	2.68		
	28.06	27.96		23.02	23.09		2.70	2.68		
	28.02	27.91		23.10	22.96					

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[1] See Bulletin No. 46, Division of Chemistry, page 12.

[2] Keldahl solution.

[3] H A and HNO_3.

[4] Dissolved in H_2SO_4—A_4.

[5] 0.5 gram.

[6] 0.5 gram, not neutralized.

[7] Not neutralized.

[8] 0.2 gram, not neutralized.

[9] Special molybdate solution. J. Am. Chem. Soc., Mar., 1896.

[10] A_4.
[11] A_6.
[12] A_2.
[13] A_5 stood overnight.
Method of solution, Bull. 46, page 12.

[14] Stood twelve hours; $Mg(NO_3)_2$, method on No. 3.

TABLE II.—*Detailed results on phosphoric acid as reported by analysts*—Continued.

Analysts.	4. Fla. phosphate. Grav.	4. Fla. phosphate. Mod. vol.	4. Fla. phosphate. Vol.	5. Ala. phosphate. Grav.	5. Ala. phosphate. Mod. vol.	5. Ala. phosphate. Vol.	6. Pottstown slag. Grav.	6. Pottstown slag. Mod. vol.	6. Pottstown slag. Vol.	(1)
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
Stillwell and Gladding, N. Y.	30.16	30.10	....	....	42.00	....	16.70	16.60	....	
John Thompson, S. C.	30.15	30.33	....	42.23	42.37	....	16.28	16.27	....	A$_5$
C. C. McDonnell, S. C.	30.17	30.18	....	42.24	27.74	....	16.26	16.34	....	
	30.15	....	....	42.35	....	....	16.28	....	....	(2)
F. S. Shiver, S. C.	30.16	30.25	....	42.35	42.10	....	15.91	16.03	....	(3)
	....	31.68	31.30	....	45.69	43.90	....	16.48	16.60	A$_4$
	....	31.55	31.05	....	44.08	42.85	....	16.74	16.50	
	....	....	30.10	....	....	42.85	....	....	15.95	
	....	....	30.75	....	....	43.30	....	....	15.80	
	....	....	29.95	....	....	42.85	....	....	16.50	
	....	....	31.05	....	....	....	....	....	....	
	....	....	[4]29.45	....	....	[4]42.30	....	....	[4]15.85	
A. M. Peter, Ky.	[5]30.04	[5]30.15	[6]30.45	[5]42.14	[5]42.50	[6]42.90	[5]16.14	[5]16.45	[6]16.25	
	....	[7]31.70	[6]30.75	[5]42.16	[7]45.60	[6]43.10	[5]16.17	[7]17.00	[6]16.23	
	....	....	....	....	[7]43.20	....	....	....	....	
	....	....	....	....	[7]43.60	....	....	....	....	
	....	....	....	....	[7]44.00	....	....	....	....	
H. E. Curtis, Ky.	30.11	30.92	30.45	43.54	43.92	43.40	16.66	16.48	16.05	(8)
	30.09	....	....	43.24	....	....	16.63	....	....	
	....	....	....	43.08	....	....	....	....	....	
	....	....	....	[9]42.68	....	....	[9]16.25	....	....	
Ora K. Knight, Me.	[10]29.99	29.92	....	[10]42.44	42.28	....	[10]15.97	15.40	....	
	[10]30.08	29.92	....	[10]42.62	42.32	....	[11]16.03	15.53	....	
	....	[12]29.88	....	....	[12]42.03	....	[13]15.99	[12]15.48	....	
C. B. Williams, N. C.	29.21	29.08	29.86	41.31	41.19	41.59	15.76	15.52	16.31	
	29.33	29.20	29.93	41.48	41.54	....	15.61	15.87	16.21	
C. D. Harris, N. C.	29.37	....	....	41.13	....	....	15.66	....	....	
	29.24	....	....	41.33	....	....	15.67	....	....	
E. G. Runyan, D. C.	30.22	30.05	29.90	42.26	42.23	41.90	16.08	15.75	15.80	
W. L. Mitchell, Conn.	30.59	30.29	....	42.79	42.92	....	16.26	16.14	....	(14)
	30.55	30.24	....	42.60	42.99	....	16.36	16.14	....	
	30.60	30.39	....	....	42.93	....	16.29	....	....	
	....	30.59	....	....	42.80	....	....	....	....	
	....	30.40	....	....	....	....	....	....	....	
	[11]29.94	....	....	[11]42.88	....	....	....	....	....	
	[13]30.01	....	....	[13]42.64	....	....	....	....	....	
	[13]29.91	....	....	....	....	....	....	....	....	
C. H. Jones, Vt.	[15]30.30	[16]30.20	....	[15]42.51	[16]42.53	....	[15]16.36	[16]16.45	....	
	....	[17]30.25	....	[8]42.60	[17]42.50	....	[8]16.44	[17]16.45	....	
	....	[8]30.40	....	....	[8]42.60	....	....	[8]16.55	....	
B. O. White, Vt.	[15]30.40	....	....	[15]42.64	....	....	[15]16.40	....	....	
W. H. Andrews, N. Y.	30.16	30.60	200 cc H^{2}O	42.50	42.55	200 cc	[18]16.39	16.10	....	
	30.18	30.65		42.76	42.72		[19]16.08	16.12	....	
	30.28	30.70		42.32	42.80		[19]16.08	....	....	

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[1] See Bulletin No. 46, Division of Chemistry, page 12.

[2] Dissolved in H_2SO_4 and KNO_3.

[3] Volumetrics stood over night.

[4] Dissolved by A$_7$.

[5] Dissolved by A$_5$.

[6] HA and HNO_3.

[7] Keldahl solution.

[8] A$_2$. Method of solution, Bull. 46, page 12.

[9] H_2SO_4.

[10] 0.5 gram.

[11] 0.5 gram, not neutralized.

[12] Not neutralized.

[13] 0.2 gram, not neutralized.

[14] Special molybdate solution. J. Am. Chem. Soc., Mar., 1896.

[15] A$_4$.

[16] A$_5$.

[17] A$_5$ stood overnight.

Method of solution, Bull. 46, page 12.

[18] Precipitated once with molybdate.

[19] Precipitated twice.

TABLE II.—*Detailed results on phosphoric acid as reported by analysts*—Continued.

Analysts.	4. Fla. phosphate.			5. Ala. phosphate.			6. Pottstown slag.			[1]
	Grav.	Mod. vol.	Vol.	Grav.	Mod. vol.	Vol.	Grav.	Mod. vol.	Vol.	
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
W. H. Andrews, N. Y.	....	30.65	300 cc	....	42.68	300 cc	....	....	....	
	....	30.60								
A. D. Cook, N. Y.	30.28	30.38	....	42.40	42.50	....	16.24	16.08	....	
	30.44	30.55	....	42.32	42.32	....	16.34	16.08	....	
C. W. Norris, Pa.	30.30	31.45	31.12	43.02	44.39	44.04	[2] 16.81	16.79	16.79	
	30.20	31.65	31.16	42.91	44.05	43.81	[2] 16.66	16.98	16.69	
	30.19	31.26	31.12	42.64	44.34	44.19	[2] 16.57	....	16.50	
	30.19	....	....	42.98	....	....	[2] 16.65	....	....	
	30.30	....	....	42.66	....	....	[2] 16.76	....	....	
	30.25	....	....	....	....	....	[2] 16.67	....	....	
F. P. Veitch, Md.	29.91	29.95	....	42.65	42.10	....	16.43	16.60	....	
	30.03	[3] 30.00	....	42.57	42.19	....	16.27	16.65	....	
	....	[3] 29.80	....	42.66	[3] 42.32	....	16.27	[2,3] 16.50	....	
	....	....	....	....	[3] 42.32	....	16.52	[2,3] 16.55	....	
	....	....	....	....	....	....	16.20	[2,3] 16.49	....	
	....	....	....	....	....	....	16.65	....	....	
W. Skinner, Md.	30.09	30.00	....	42.28	42.00	....	16.62	16.60	....	
	30.15	30.10	....	42.46	41.95	....	16.65	16.55	....	
	30.18	30.02	....	42.36	41.95	....	16.62	16.48	....	

[1] See Bulletin No. 46, Division of Chemistry, page 12.

[2] Used diluted acid in dissolving.

[3] Stood twelve hours; $Mg(NO_3)_2$, Method on No. 3.

TABLE III.—*Phosphoric acid by "yellow method."*

Analysts.	Sample.					
	1.	2.	3.	4.	5.	6.
Stillwell and Gladding	28.10	22.76	2.56	30.15	42.20	16.60
	28.20	22.76	2.58	30.15	42.11	16.70
Average	28.15	22.76	2.57	30.15	42.16	16.65
E. G. Runyan, U. S. Dept. of Agr.	28.28	23.01	2.61	30.27	42.41	15.90
O. W. Knight, Me. (dried in water oven)	28.24	23.30	2.44	29.95	42.44	16.11
	28.20	23.30	2.59	....	42.46	16.00
Average	28.22	23.30	2.52	29.95	42.45	16.06
C. W. Norris, Pa. (Dried in ordinary air bath at 105–112° C.)	28.02	22.93	2.67	30.13	42.64	16.22
	28.42	22.97	2.74	30.51	43.27	16.69
	27.94	23.15	2.53	30.95	42.14	17.18
	....	....	2.47	29.82	....	....
Average	28.13	23.02	2.60	30.35	42.68	16.70

NOTES OF ANALYSTS.

T. S. Gladding.—I find the same results by all three methods for P_2O_5. The gravimetric is least reliable. The volumetric is all right when solutions are accurate. My gravimetric "yellow method" I find most *certain* in the hands of our assistants. Its simplicity and gravimetric features are its strong points.

A. M. Peter, Kentucky.—We have had a great deal of trouble in working with the volumetric methods, and have not succeeded in getting good results, especially on the sulphuric-acid solutions. You will notice when you compare my results with those of Mr. Curtis that there is also a considerable discrepancy between his figures and mine on samples Nos. 5 and 6 by the gravimetric method. It would appear that the results obtained from sulphuric-acid solutions by the official gravimetric method are considerably too high and that the duplicates do not agree where there is much iron and alumina.

H. E. Curtis, Kentucky.—Quite a number of determinations have been made on hydrochloric and nitric acid solutions on these same samples, but the methods varied slightly from both yours and Mr. Kilgore's, and as yet I have not been able to get duplicate results to agree. In some sets they would agree and the same work would be duplicated, and the duplicates would not agree, neither would they agree with the former results.

O. W. Knight, Maine.—In the Gladding method I used Gooch crucibles. After four hours drying in the water oven, a constant weight was reached by the precipitate. This method gives good results and seems likely to prove of value in some cases.

In the volumetric method there is great difficulty in determining the exact moment when the color change takes place. Some of the precipitate begins to dissolve in many cases before it is thoroughly washed.

C. B. Williams, North Carolina.—In the gravimetric method twenty washings were required to rid the white precipitate of chlorids.

In washing the yellow precipitate free from nitric acid, in determining phosphoric acid by your modification of the volumetric method, it was found that it required from twelve to fifteen washings, while by Kilgore's method six were sufficient.

In the manipulation of your modification the following objections are encountered: First, in consequence of the low temperature of precipitation the yellow precipitate obtained is in such a finely divided condition that it tends to run through the filter paper; second, the washing of the ammonium phosphomolybdate is so slow that there is great danger of decomposition of the yellow precipitate taking place; third, the amount of filter paper is necessarily so large in the titrating beaker that it interferes with the detection of the exact neutral point in titration. In Kilgore's method none of these objections has to be contended with. In all volumetric determinations 20 cc solutions, corresponding to 0.2 gram substance, were used. All results are from the same solution.[1]

C. H. Jones, Vermont.—I am of the opinion that if a volumetric method is to be adopted officially your modification is more nearly correct than the one printed (in Bul. 46).

Winton (Mitchell), Connecticut.—* * * Used modified molybdic solution as described in the Journal of the American Chemical Society, May, 1896.

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[1] Note by referee.—I am unable to reconcile all of the statements above with the results reported by Mr. Williams. The averages of his results, which are from closely agreeing duplicates, are as follows:

Sample.	Gravimetric.	Referee's volumetric.	Kilgore's volumetric.
No. 1	27.37	27.51	27.80
No. 2	22.35	22.34	22.78
No. 3	2.57	2.61	2.62
No. 4	29.27	29.14	29.90
No. 5	41.40	41.37	41.59
No. 6	15.69	15.70	16.26

In every case the referee's method gives results very close to the gravimetric, while in each case higher results are obtained by Kilgore's method. I do not think that the latter precipitates were sufficiently washed.

We do not think that the ammonium nitrate contained in the ordinary molybdic solution is sufficient when no more is added or formed by neutralization. As we ignite fertilizers containing organic matter with magnesium nitrate and dissolve in HCl we get no nitrate by neutralization of the solvent. We have our choice of four plans of procedure if we wish more ammonium nitrate than moderate excess of molybdic solution will furnish: (1) Addition of HNO_3 and NH_4OH; (2) addition of solid or dissolved NH_4NO_3; (3) addition of large excess of molybdic (the old way); (4) use of molybdic solution containing the extra NH_4NO_3. The latter plan seems to me preferable from point of convenience. * * *

The few determinations I have made convince me that the volumetric method, both as Kilgore left it and in the form you use it, is, when carefully carried out, thoroughly accurate. The following experiments may be of interest to you:

SERIES I.—Added HNO_3 and neutralized with NH_4OH.

Determination.	Volumetric.	Gravimetric.
	Per cent.	*Per cent.*
Total phosphoric acid in acid phosphate	17.40	17.28
Total phosphoric acid in tankage	14.83	15.05
Total phosphoric acid in dry ground fish	7.39	7.28
Total phosphoric acid in dissolved bone black	17.26	17.24
Total phosphoric acid in air-dry carnation blossoms	.65	.63
Total phosphoric acid in mixed fertilizer	6.44	6.33

SERIES II.—Added solid NH_4NO_3.

Determination.	Volumetric.	Gravimetric.
	Per cent.	*Per cent.*
Total phosphoric acid in dry ground fish	6.89	6.87
Total phosphoric acid in mixed fertilizer	11.03	10.87
Total phosphoric acid in mixed fertilizer	12.39	12.22
Total phosphoric acid in mixed fertilizer	12.04	11.88
Total phosphoric acid in mixed fertilizer	11.08	10.98
Total phosphoric acid in mixed fertilizer	10.57	10.43
Total phosphoric acid in mixed fertilizer	2.07	1.95
Soluble phosphoric acid in mixed fertilizer	7.04	6.98
Soluble phosphoric acid in dissolved bone black	12.04	11.89

SERIES III.—Using molybdic solution containing extra NH_4NO_3.

Determination.	Volumetric.	Gravimetric.
	Per cent.	*Per cent.*
Soluble phosphoric acid in mixed fertilizer	2.60	2.46
Soluble phosphoric acid in mixed fertilizer	2.40	2.32
Soluble phosphoric acid in mixed fertilizer	4.75	4.61
Soluble phosphoric acid in mixed fertilizer	9.03	8.94
Soluble phosphoric acid in mixed fertilizer	4.75	4.65
Soluble phosphoric acid in mixed fertilizer	6.69	6.51

F. P. Veitch, Maryland.—Washings in the volumetric method were from twelve to twenty-four times, amounting to from 150 cc to 250 cc on each sample, the larger amount being required by the heaviest precipitates.

I have found it safer to use 1 cc of 1 per cent phenolphthalein, as with a smaller amount the color fades too soon, giving slightly high results.

OBSERVATIONS BY REFEREE.

It is worthy of note that outside of the referee's laboratory only three of the chemists taking part in this work did so last year. Taking this into account, and also the nature of the samples, I consider this work very good indeed. There are very few wild results by the gravimetric method, and only a few by the modified volumetric method, and those are confined to three or four analysts. The average results by the latter give a better showing than those by the published method. To be sure, the variations are less by the latter method, but this loses weight when we remember that three times as many chemists tried the new modification.

I wish to again call the attention of the association to the optional method for preparing ammonium citrate. At the Chicago meeting I called attention to this method. In the first place, it is supposed that on mixing two solutions which react on each other, causing a precipitate, the filtrate will still be neutral, provided the original solutions are neutral. Although this is the rule, there are some well known exceptions. Let us examine the method. "Dilute to nearly sp. gr. 1.09. Prepare calcium chlorid solution; make the latter neutral. To 10 cc citrate add 50 cc calcium chlorid solution. (This dilutes the citrate to one-sixth.) Filter and *dilute* the filtrate with an equal volume of water," making the acidity or alkalinity one-twelfth of the original citrate. Anything can be made neutral to the ordinary tests by the process of dilution alone, if it be carried far enough.

In the referee's laboratory the best method yet found for preparing citrate of ammonia is that of De Roode. The citric acid is put into a large evaporating dish or enameled iron pan and covered with water; ammonia is added from time to time, regulating the amount so that the hea tgenerated will not be extreme, till it is in decided excess; the dish or pan is then allowed to stand, uncovered, for about two days, when the solution will be found to be neutral. It is then diluted to the proper specific gravity.

RECOMMENDATIONS.

1. That the volumetric method, in its simplified form, be adopted as an alternate method.
2. That the De Roode method for the preparation of ammonium citrate be tested by the referee the coming year with the view of adopting it instead of the present "optional" method.

DETERMINATION OF IRON AND ALUMINA. (TABLE IV.)

Sample No. 8 was made up by using chemically pure salts, and contained one part of ferrous ammonium sulphate, one part of aluminum sulphate, and two parts of tricalcium phosphate. It contained, as nearly as could be determined from analysis of the ingredients, from 4 to 4.05 per cent of Al_2O_3 and from 5.10 to 5.15 per cent of Fe_2O_3. Analysis showed the following composition of the ingredients:

	Per cent.
Fe_2O_3 in iron ammonium sulphate, by precipitation with ammonia	20.40
	20.46
By titration with permanganate	20.26
	20.26

Average, 20.36 per cent; theory, 20.40 per cent.

	Per cent.	Per cent.
Al_2O_3 in aluminum sulphate	15.95 (Veitch);	15.94 (Bomberger).
	15.66	15.93

Average, 15.95 per cent.

The calcium phosphate used gave 0.36 per cent of iron and alumina phosphates by the acetate method. This result is thought to be considerably too high, but the determination was not repeated. The solution gave a slight reaction for iron by qualitative test.

TABLE IV.—*Results on iron and alumina.*

Analysts.	1. S. C. rock.			4. Fla. phosphate.			5. Ala. phosphate.		
	Acetate.	Thio.	Glaser.	Acetate.	Thio.	Glaser.	Acetate.	Thio.	Glaser.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
C. Glaser, Balto	....	1.14	1.90	....	2.23	2.26	....	29.57	29.63
	....	0.77	1.75	....	....	....	....	....	29.63
	....	1.11	1.84	....	....	....	....	....	....
F. S. Shiver, S. C.[2]	2.07	....	....	2.35	....	....	29.44	....	....
	[3]1.95	....	....	[3]2.37	....	....	29.48	....	....
E. G. Runyan, U. S. Dept. of Agr	1.86	1.17	1.15	2.39	1.40	0.80	27.90	27.58	24.70
F. P. Veitch, Md	1.70	1.50	....	1.94	1.75	....	27.12	27.81	....
		By K MnO_4.			By K MnO_4.			By K MnO_4.	
C. Glaser	....	[4]3.12	3.08	....	[4]1.45	1.47	....	10.85	10.75
	....	[5]3.19	....	....	....	....	....	....	10.80
F. S. Shiver	....	2.51	....	....	1.43	....	....	10.46	....
E. G. Runyan	2.87	3.30	3.10	1.50	1.42	2.16	11.60	11.32	12.14
F. P. Veitch	3.06	2.94	....	1.45	1.58	....	11.26	10.81	....

Analysts.	6. Pottstown slag.			8. $Al_2(SO_4)_3$; Fe *Am* SO_4; $Ca_3(PO_4)_2$.				
	Acetate.	Thio.	Glaser.	Acetate.	Thio.	Glaser.	Glad. potash.	
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
Stillwell & Gladding, N. Y.	....	....	....	....	5.07	....	4.05	Al_2O_3.
	....	....	....	....	5.11	....	4.01	
	....	....	....	....	3.60	....	4.01	
C. Glaser, Balto	....	[1]2.71	0.08	....	4.09	4.10	....	
	....	....	0.16	....	4.03	3.96	....	
F. S. Shiver, S. C.[2]	0.30	....	....	3.77	....	....	....	
	0.18	....	....	3.79	....	....	....	
	....	....	....	[3]3.87	....	....	....	
E. G. Runyan, U. S. Dept. of Agr	0.50	0.78	0.27	3.72	3.22	3.28	....	
F. P. Veitch, Md	0.75	0.59	....	3.47	3.95	....	....	
		By K MnO_4.			By K MnO_4.			
Stillwell & Gladding, N. Y.	....	....	....	....	....	....	4.92	Fe_2O_3.
	....	....	....	....	....	....	4.93	
C. Glaser	....	21.42	20.29	....	5.69	5.35	....	
	....	....	21.79	....	....	5.40	....	
F. S. Shiver	....	22.38	....	....	5.13	....	....	
E. G. Runyan	23.10	23.80	22.30	5.60	5.78	6.20	....	
F. P. Veitch	22.55	22.00	....	5.14	5.17	....	....	

[1] Mostly SiO_2.

[2] Results by subtracting Fe_2O_3 from iron and alumina.

[3] Jones—Acetate method.

[4] Precipitated in 50 cc in presence of citric acid by Am. sulphid.

[5] By nitroso β naphthol.

The preliminary work on methods was done by Mr. F. P. Veitch, who got very promising results in some preliminary work by using sodium thiosulphate for the determination of alumina. Mr. Veitch got some suggestions from Blair's Analysis of Iron and Steel and one or two other places, and thought the reagent could be used for the present purpose. In later work the method did not prove all that could be desired. Some of the preliminary work done is as follows:

Prepared three solutions, 1 liter of which contained the substances and amounts of same as given below.

Composition of samples.

No. 1.	No. 2.	No. 3.
16 gms. $Ca_3(PO_4)_2$.	14 gms. $Ca_3(PO_4)_2$.	1.500 gms. $CaCl_2$ (fused).
0.4 gm. $MgCl_2$.	0.2 gm. $MgCl_2$.	4.000 gms. Na_2HPO_4.
0.2 gm. NaCl.	0.2 gm. NaCl.	0.500 gm. $MgCl_2$.
0.2 gm. KCl.	0.8426 gm. Fe.	0.250 gm. Fe (wire).
0.2902 gm. Fe.	3.0082 gms. $Al_2(SO_4)_3.18H_2O$.	2 gms. $Al_2(SO_4)_3.18H_2O$.
7.0050 gms. $Al_2(SO_4)_3.18H_2O$.		

Fifty cubic centimeters of these solutions were used in each case for analysis. The acetate method was carried out according to instructions given, except as noted.

Caustic-potash method.

Precipitated in a 100 cc flask with excess of KOH, let stand one hour at 70°, cooled, made up to mark, filtered, and used 50 cc of filtrate for determination. Aluminum was precipitated with ammonium acetate as $AlPO_4$, filtered, washed, ignited, and weighed. Iron was determined by the permanganate method.

Thiosulphate method.

Precipitated according to directions already given. Ignited and weighed the precipitate without treating it with KOH.

Comparison of results.

Methods.	Solution No. 1.		Solution No. 2.		Solution No. 3.	
	Fe_2O_3.	Al_2O_3.	Fe_2O_3.	Al_2O_3.	Fe_2O_3.	Al_2O_3.
	Gram.	*Gram.*	*Gram.*	*Gram.*	*Gram.*	*Gram.*
Theory	0.0207	0.0558	0.0602	0.0239	0.0179	0.0159
Acetate method:						
Single precipitation	.0262	.0560	.0677	.0240	....	....
Double precipitation	.0246	.0560	.0597	.0228	....	....
Potash method	.0207	.0580	.0594	.0221	....	....
	.0200		.0602			
Thiosulphate method	.0207	[1].0535	.0594	[1].0249	....	[1].0165
	.0210	[1].0563	.0602	[1].0249	....	[1].0165
	....	[2].0523	....	[2].0236	....	[2].0151
	....	[2].0535	....	[2].0228	....	[2].0150

[1] Precipitated in presence of acetic acid.

[2] No acetic acid. Dissolved in KOH and reprecipitated.

NOTES OF ANALYSTS.

T. S. Gladding, New York.—The Gladding method, as published, was employed with one modification, as follows: An aliquot, 50 cc, of the solution (of 4 grams in 200 cc), containing 1 gram, was placed in a 200 cc flask, 20 cc of 50 per cent solution of c. p. KOH added, digested for thirty minutes in boiling water bath, cooled, filled to mark, mixed, filtered, and 100 cc of filtrate, equal to one-half gram, treated as directed. The complete analysis requires only from one and one-half to two hours when pump is used.

C. Glaser, Baltimore.—Have modified my method as follows: (Chem. Zeit., 1897, 21, No. 69.) The solution of the phosphate is freed from lime as much as possible by means of a precipitation by ammonium acetate, or by precipitation of calcium sulphate, according to the method of E. Glaser. The solution, freed from lime, is approximately neutralized. After cooling, dry sodium peroxid is added, in small portions, until a clear solution is obtained; from 3 to 6 grams will usually suffice on 0.4 gram of substance. Now boil for a short time, let settle, and pour through a thick ashless filter. In the filtrate determine alumina, after acidulation, by any convenient method, preferably by precipitation twice, as $AlPO_4$ (after the addition of a little pure phosphoric acid), by means of ammonium acetate.

The iron upon the filter is dissolved in warm, dilute HCl, and after purification by first precipitating it with nitroso-β-naphthol or ammonium sulph-hydrate, the latter in the presence of citric or tartaric acid in ammoniacal solution, the precipitate is dissolved in acid, oxidized, precipitated as hydroxid, and weighed as oxid.

F. S. Shiver, South Carolina.—Worked acetate method according to Bulletin 21, page 5, South Carolina Experiment Station.

Referee.—The results are too few by any of the methods to admit of much comparison or the drawing of very definite conclusions. There are more results reported on iron by the permanganate method than by any other, and with a few exceptions they agree fairly well. This seems to be the best method for the determination of iron in phosphates. The most promising method for alumina, in my opinion, will be found to be that of Gladding—the potash method.

I would recommend that the work be continued next year.

TABLE V.—*Results of analysis of basic slag.*

Analysts.	"Available" by ammonium citrate.				Available by Wagner's method.		Solubility in 1 per cent citric acid at about 20° C.			
	½ hour.		1 hour.				1 hour.		2 hours.	
	No. 6.	No. 7.	No. 6.	No. 7.	No. 6.	No. 7.	No. 6.	No. 7.	No. 6.	No. 7.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
John Fields, Okla	......	......	......	......	[1]11.05	[1]12.81	6.96	7.47	7.70	8.56
					[1]11.05	[1]12.89	6.83	7.52	7.67	8.34
					[2]11.74	[2]14.38	6.88	7.52	7.70	8.68
					[2]11.74	[2]14.48				
C. Glaser, Balto	......	[3]6.67	......	[3]7.37	[1]11.11	[1]13.72				
		[4]6.91		[4]7.75						
H. E. Curtis, Ky	[5]5.43	[6]6.62	[5]5.98	[6]7.32	......	......	7.52	8.14	7.92	8.78
E. G. Runyan, U. S. Dep. Agr.	6.70	7.72	6.53	8.16	[7]11.76	[7]14.34	[8]7.45	[8]7.55	[8]8.03	[8]8.74
Huston and Jones, Ind	5.34	6.10	5.62	6.89	12.04	24.46	7.59	8.25	8.09	9.49
	5.39	6.03	5.68	6.89	11.97	14.46	7.52	8.44	7.92	9.49
		6.10					7.52			
		6.12								
C. W. Norris, Pa	......	......	......	......	[1]11.11	[1]12.95	[9]8.34	[9]9.31	[9]8.73	9.67
					[1]11.15	[1]13.05	[9]8.22	[9]9.10	[9]8.85	9.72
								[9]8.99		
Veitch, Md	6.72	8.93	7.05	9.54	[11]11.85	[11]13.90	[10]9.81	[10]11.64	[10]9.98	[10]12.72
	6.61	9.16	7.09	9.44	[11]11.85	[11]14.30	[10]9.62	[10]11.56	[10]9.96	[10]12.68
		8.87				[11]14.27				[10]12.49
					[11]11.94	[11]14.04				

[1] Shaken by hand 6 times per minute.

[2] Shaken by hand continuously.

[3] Molybdate method.

[4] Citrate method without reprecipitation.

[5] By difference, association average for total.

[6] By difference, Skinner's total.

[7] At 29° C.

[8] At 28° C.

[9] Citrate method.

[10] 20° C.

[11] Refined two hours for complete precipitation.

TABLE V.—*Results of analysis of basic slag*—Continued.

Analysts.	Mechanical analysis.									
	No. 6.					No. 7.				
	Retained by ½ mm. sieve.	Pass above. Retained by silk, 4 meshes to mm., No. 5.	Retained by silk.	Pass silk, 4 meshes to mm., No. 13.	Pass silk No. 20.	Retained by ½ mm. sieve.	Retained by silk, 4 meshes to mm., No. 5.	Retained by silk, 5 meshes to mm., No. 13.	Pass silk No. 13.	Pass silk No. 20.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
E. G. Runyan, U. S. Dep. Agr.	0.03	0.10	43.14	56.53	....	4.25	3.66	41.79	50.14	
Huston and Jones, Ind ..	.07	.17	[1]29.84	[1]68.66	....	[1]2.86	[1]1.73	[2]32.67	62.74	
			[1]31.11	[1]69.92		[1]3.25	[1]1.66	[2]32.05	63.04	
			[2]25.16	[2]74.60						
			[2]25.44	[1]74.56						
Laughlin, Md..........	.00	.00	28.80	71.20	54.72	3.66	4.13	39.70	52.51	41.08
										41.04

Analysts.	Removed by magnet.		Total P_2O_5.	
	No. 6.	No. 7.	No. 6.	No. 7.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
E. G. Runyan, U. S. Dep. Agr	1.96	0.83	16.08	18.07
Huston and Jones, Ind	[3]13.13	[4]4.33	16.20	18.21
	[4]10.19	[4]4.96	16 21	18.10
	[4]10.06	[4]4.39		
	[4]11.01	[4]5.46		
Veitch (chem.) and Laughlin (mechanical anal.), Md........	....	[5]81.25	....	[6]18.12
		[5]81.34		
	[7]2.17	[7]1.13		

[1] Shaking sieve.

[2] Rubbed through with camel's hair brush.

[3] Dipped into slag.

[4] 100 times across at 1½ mm.

[5] In contact.

[6] Skinner.

[7] Not in contact

The slags used in these experiments were analyzed for me by Mr. H. C. Sherman, then of my laboratory staff, with the following results:

Analyses of slag.

Constituents.	No. 6.	No. 7.
	Per cent.	*Per cent.*
SiO_2	5.95	8.19
P_2O_5	[1]16.30	[2]18.12
S	.25	.23
CO_2	1.82	1.29
FeO	13.42	11.19
Fe_2O_3	[3]6.20	5.61
Al_2O_3	1.60	1.86
MnO	4.84	4.40
CaO	46.22	43.58
MgO	1.22	.81
H_2O	.62	.35
Total	97.44	95.73

[1] Veitch.

[2] Skinner.

[3] Based on Veitch's total iron.

NOTES OF ANALYSTS.

H. A. Huston.—From the results obtained and the observations made during the work I am of the opinion that the work with the magnet is of very little account. If the magnet be allowed to come directly in contact with the slag, practically all of the slag will adhere to the magnet. * * * Odor of H_2S was given off in all cases upon uncorking flasks after treating slag with citric acid or acid citrate.

Referee.—It is also the opinion of the referee that the work with the magnet is of no account. Also that the mechanical analysis is not of much value, unless, perhaps, a system of determining available might be based on such determinations, taken in connection with the determination of total phosphoric acid.

The results with the official citrate of ammonia are somewhat discordant; also those with citric acid. The results by the Wagner method are very good considering the various methods used for agitating the flasks. If it appear that basic slag gives as good results in the field as are obtained by acid phosphates I think the Wagner method is probably the best we have at present.

The referee has no recommendation to make, however.

The president called for papers relating to the analysis of matters containing phosphoric acid.

ESTIMATION OF IRON AND ALUMINA IN MINERAL PHOSPHATES.

By G. W. Lehmann.

It is understood that all reagents used must be strictly c. p., and ashless filters used. Two grams of substance are dissolved in sufficient HCl and one or two cc of HNO_3. Evaporate to sharp dryness on water bath. Take up with a few drops of HCl, filter, and make up to 250 cc. Remove 50 cc (equal to 0.4 gram substance) to 8-ounce beaker. If only a few drops of HCl have been used neutralizing is not necessary, as the few drops are just enough to hold the Ca in solution; should more HCl have been needed, nearly neutralize the 50 cc with NH_4O. Add, carefully, solution of ammonium acetate until precipitate forms, then add 5 cc in excess, stirring vigorously, and keep for twenty minutes at a temperature *not exceeding* 70° C. Filter, wash well with tepid water; dissolve residue on filter with warm dilute HCl into 8-ounce beaker, nearly neutralize with NH_4O; increase volume in beaker, if necessary, by adding water to about 75 cc, and add carefully in four or five portions about 2 grams sodium peroxid. This quantity of sodium peroxid will, in most cases, be sufficient to render the solution for a moment perfectly clear and of red-brown color. Place beaker on asbestos plate and boil at once for two or three minutes, when all the Fe_2O_3 will be precipitated and collected at the bottom of the beaker. Filter and wash with hot water. To filtrate, add a few drops of microcosmic salt solution, add HCl until acid nearly neutralizes with NH_4OH, add ammonium acetate, proceed as stated before, repeat this process a second time with the exception of this time adding a few drops of P_2O_5 solution in place of the microcosmic salt; filter, incinerate as usual ($AlPO_4$).

The red Fe_2O_3 precipitate on filter is dissolved with warm dilute HCl. Add to filtrate sufficient concentrated citric acid solution to hold Fe_2O_3 in solution (about 5 cc); make strongly ammoniacal; add about 10 cc strong ammonium sulphid solution, stir vigorously for two minutes, allow to settle, filter, and wash very thoroughly with ammonia water to which a little $(NH_4)_2S$ solution has been added until every trace of citric acid is removed. Dissolve the iron sulphid on filter with warm dilute HCl, add a few drops of HNO_3, boil, add NH_4OH, boil to facilitate quick filtration, let settle, filter, incinerate as usual (Fe_2O_3). Time, about three hours.

DISCUSSION ON BASIC SLAG.

Mr. HUSTON. I would especially request the referee that, in connection with the complete analyses of these slags which he quoted, he give us the minutest details of the method of analysis. I have tried every published method which I can find for the complete analysis of slag, and in the hands of myself and my assistants they are all absolutely worthless. They give manganese strung along over the whole course of analysis, and we have not been able to remove that difficulty. I notice that no titanium is reported. One slag, at least, contains titanium, which interferes very seriously with the determination of iron by any volumetric method. The electrolytic methods for the determination of iron are quite worthless with these materials. In fact, we only disintegrated our platinum electrodes without being able to do anything with the method. Yet it is only by the electrolytic method that we have been able to get anything approaching a satisfactory determination in these slags. With that we have, we think, got something which we can get twice alike, at any rate. We have not yet been able to overcome the trouble with manganese. I would not be surprised if we found this same difficulty with other phosphates in which iron is so high that it can not all be precipitated as the ordinary phosphate that we find in the acetate method. Here we have much more iron than we are accustomed to meet with, and it requires enormous quantities to add to this solution to precipitate all the phosphorus, if it be desired to get rid of it that way. Even acid precipitation with calcium sulphate carries a large quantity of manganese with it in this work. So I especially request that we be given the minutest details of the analysis of this material. It is of the utmost importance in connection with the analysis of slag that we should know of what this slag is composed. I believe the percentage of manganese in these slags is going to play an important part in connection with the available phosphorus in them. We will finally, I think, have to know with accuracy the composition of these slags, and, so far as I have been able to find methods, none of them is satisfactory.

In regard to the matter of the neutralization of the citrate solution, we have tried the method spoken of, which is, as I recall it, letting things stand around for twenty-four hours and it is then neutral. The first trial we made of this was highly satisfactory, although I confess we used our calcium chlorid method to determine whether it was neutral, but a number of other trials was decidedly unsatisfactory. The things were very far from neutral, even with litmus paper, but men who were doing research work on citrate solutions in my laboratory were entirely unwilling to work with such solutions.

Mr. SCOVELL. We do not claim that we have any exact method for determining available phosphoric acid in basic slag, but we find we get more concordant results and a smaller percentage if we treat our yellow precipitate at 40° instead of 65°. The old method of heating the precipitate was at 40° and we changed it to 65°, but if it be heated at 40° it will do better. In fact, I am making some experiments, on which I am not ready to report, in which we precipitate in the cold and we find still better results. It will settle in five or ten minutes. I find this the quickest and easiest way to do it.

Mr. Huston. I would like to discuss a little more this matter of work with a magnet on these slags. I suppose the idea of treating slag with a magnet is to remove the actual iron there, and I presume the idea was imported from Europe along with the slag. The determination of what is actually removed from the slag by the magnet shows that that material contains from 8 to 12 per cent of phosphoric acid—the material which actually adheres to the magnet. In our method, the slag is put on a glass plate, and the magnet, which is about the size of a lead pencil, is placed so that it can not come within 1.5 millimeters of the slag. It is then passed over it fifty times in one direction and fifty times crosswise. The operation is tedious, but it works after a fashion. Yet we found that even with these precautions from half to two-thirds of the phosphorus was removed by this method, so I think the use of the magnet is not at all desirable. I think it should be abandoned altogether. The actual amount of real metallic iron I think is very small.

In regard to the fineness of the sample, especially where material like bolting cloth is to be used, I think very explicit directions should be given as to how it is to be used; whether we are to shake the material, or whether we are to brush it. It makes a great difference in determining the fineness, and I believe we should adopt some very explicit directions.

The matter of the solution of slags in citric acid I think is a rather difficult one. As we have already shown, in about one and a half to two hours the amount of phosphorus dissolved reaches a maximum and afterwards falls off rapidly, while the acid continues to be neutralized. If we are working at higher temperatures the maximum amount of phosphorus dissolved is reached at a much earlier point. In view of the very complicated composition of citrates of iron, it seems to me there is very little hope of arriving at any concordant results or anything suitable for a commercial method by treating slags with citric acid, although it has been very strongly recommended. This brings us right back to the position that we shall finally be forced to value slags upon the fineness and total contents of phosphoric acid. In connection with the method just discussed for determining iron and aluminum, we would have again to look for the titanium. I believe that the volume of the solution has a great deal to do with the amount of phosphorus removed. We have done a good deal of work on this subject. It is not final, and I am not yet ready to report on it. Dr. Wiley has his little joke on me for dissolving slag in water; but it is not so funny as it seems to be, for a considerable quantity of basic slag will dissolve in water. I believe the difference between the official citrate we use and the Wagner method is very largely due to the relation between the amounts of slag taken and the volume of fluid used. It is due more to that than to the acidity of the solution. We can very much increase the amount of phosphorus removed from basic slag by the use of the official solution if we simply add the citrate solution's own volume of water to it. We are now working upon that, trying to get something a little more definite than we have already arrived at. I believe it is much more a question of volume than we have heretofore supposed.

Mr. WILEY. One remark made by the referee I would like to call attention to, and that is that the effect of the mechanical condition of the slags is of little importance. Now, it seems to me that with all these materials, not only basic slags but other mineral substances used as fertilizers, the mechanical condition is of the greatest importance, as the amount of surface which is exposed by the material is of course proportionate to the size of the particles. The finer the mechanical condition, the greater the surface exposed. Now, the solubility of a body is to a certain extent a function of its surface. Very important modifications of solubility with a given solvent are determined by the surface of exposure. So it seems to me that that remark of the referee will bear criticism. The mechanical condition of a slag is one of the first things to be determined. It is true that slag particles when placed in the soil tend to rapid decomposition, due chiefly to the slacking of the lime they contain. It is evident, however, that the finer the slag is at first the quicker will this decomposition take place. In easily soluble substances the mechanical condition is of less importance. I doubt not that the function of water as a solvent is determined largely by the surface of the bodies which are exposed. So far as that is concerned, we know that even gold and platinum will dissolve in water, at least if they contain a little salt. Gold has been found in solution in the waters of the ocean.

I do not know how we are to be sure that phosphatic slag dissolves in water alone. If I understand the composition of basic slag, it has a great deal of lime in it, and when water is added hydrate of lime is produced. The simple addition of water to powdered slag does not prove that water is a solvent, because what we have there is hydrate of lime in partial solution.

This matter of slag phosphate is one of the most interesting now before this association. We ought to introduce those new things which promise so much benefit to agriculture. I think we have reached a degree of accuracy in the analysis of ordinary nitrogen, phosphoric acid, and potash-containing bodies, which is sufficient for all practical purposes, but here comes a substance which presents some unusual peculiarities. We have the remarkable fact presented that when lime is in this certain state of combination it seems to be peculiarly assimilable by plants, and here we are brought directly in contact with the great point of union between pure chemistry and physiological chemistry in the life of the plant.

I am sorry Congress saw fit to lay a duty of $1 a ton on imported phosphatic slags. All along our farming interests have been favored, and I think justly so, in our legislation. The attempt has been made to bring in, free of duty, all those substances which are used for fertilizing purposes. I fear this duty will delay the large introduction of these phosphates. We have only one or two mills in this country, I think, which are making slag phosphate. They are making steel by the basic process, and of course are producing large quantities of slag, which will, in the course of time, be on the market. Our members will sooner or later be brought into contact with these fertilizing materials, and it may be that there will be presented to us problems different from those which we have been engaged upon. We should not only welcome the results that have been obtained in these matters, but the referee for next year should be instructed to continue the investigations with regard to the solubility of basic slags and to their properties as plant food. The experience of ten years is not to go for nothing. It has been certainly proved that these slags have a high agricultural value. I would like to see the association push forward this work. We are not in condition to adopt any method as official. As the results show, the Wagner method has given the most concordant results among a number of analysts, and we can not do better than hold on to it as a provisional, not an official, method. Later we may reach a position when we can adopt an official method which will be enjoined upon us all, but this, I think, is not possible at the present time. This whole matter seems to me to bring up a subject which we must sooner or later investigate to the bottom—namely, the true availability of phosphatic manure. Many statements and claims have been made in regard to this matter. Soft ground phosphate has been put upon the markets of this country with the claim that it is the only natural plant food. On the other hand, it has been claimed that the phosphoric acid in ground bone is worth nothing as plant food. Here we have two extremes of opinion. I know by actual experience that soft ground phosphate in some soils is efficient in feeding plants, while in others it is practically worthless, and I have a very firm conviction that the phosphoric acid of ground bone is more or less available for the uses of plants.

Mr. McDonnell. What Mr. Wiley says in regard to slag is very interesting, but I think what I said was not understood. I did not mean that it made no difference whether the slag was fine or coarse, but I meant that if we determined the availability of the slag by treating with some of these reagents, the finer the slag the more would be dissolved and the availability would be shown by the amount dissolved, without the necessity of making a mechanical analysis. If the slag be very coarse, the soluble action will be very much less, depending upon the amount of surface exposure. So I hardly thought it worth while to have both methods of determination used.

The point Mr. Huston mentioned about the use of the magnet we had observed in our laboratory before we received his report, and it will be noticed that in two determinations, Table No. 5, made in our laboratory, in the first one we removed by a magnet over 81 per cent of the slag (No. 7) where the magnet was brought in actual contact with the substance, while when it was held a very short distance away from the substance only a little over 1 per cent was removed.

Mr. Gaines. Mr. Wiley said in the course of his remarks that ground soft phosphate had been found to act well in certain soils. At the Virginia department of agriculture we receive many samples of that ground soft phosphate, the farmers stating that it is absolutely worthless. I would like Mr. Wiley to state the peculiarities of the soils in which soft phosphate was found to respond.

Mr. Wiley. I do not know whether the material could be called soil or not. It was the peat or muck soils of Florida, extremely acid and composed almost exclusively of organic matter. In experimenting with these soils in pots I found I could detect very little difference between superphosphate and soft ground phosphate. They all seemed to act very happily.

Mr. Persons. In Florida we have conducted experiments that corroborate Mr. Wiley's, and the best effects were always produced in soils containing a large amount of organic matter. In mixing fertilizers it was found that where soft phosphate was used in the presence of cottonseed meal the results would seem to be borne out there also. That is, where nitrogen was used in organic combination, the effects of the soft phosphate were much more perceptible. In my mind that is hardly a question any more; it is almost entirely settled. If we get good effects from soft phosphate it is when it is applied along with one of these soils containing large amounts of organic matter.

The President. The fact referred to was in the mind of the Chair this morning, that we might eventually be obliged to classify methods of determinations for agricultural purposes, with reference to the classes of soils upon which the fertilizers were to be applied.

Mr. McDonnell. In regard to the factor for calculating results on phosphoric acid, I wish to mention that in some sections I think the tables of Battle and Dancy are used, which give different results from the tables published by myself. On some samples in this work this would make a difference of 0.15 to 0.16 per cent between the two tables. So far as I know, the association has never adopted an official factor, but left it to each investigator.

Mr. Wiley. I move that the portion of the referee's report referring to the different methods for slags be referred to the committee, and especially with reference to the adoption of a provisional or an official method for the guidance of our members during the coming year.

Seconded, and so ordered.

The meeting was then adjourned until Wednesday morning.

SECOND DAY.

WEDNESDAY—MORNING SESSION.

The association met at 10 o'clock, and the president appointed Messrs. Penny, Van Slyke, and Fulmer a committee on nominations, to report at the afternoon session at 2 o'clock.

RECOMMENDATIONS AND DISCUSSION OF METHODS FOR PHOSPHORIC ACID.

The committee on recommendations presented the following report on methods of analysis for phosphoric acid:

> The committee recommends—
>
> (1) That the volumetric method for determination of P_2O_5 be continued another year as a provisional method, and that the referee for next year be asked to continue work on this method.
>
> (2) That a continuation of the study of methods of analysis of Thomas slag be made.
>
> (3) In regard to iron and alumina, that methods for determination of these substances in phosphate be further investigated.

Mr. Bartlett. Referring to the referee's first recommendation in regard to the volumetric method, the committee, after thoroughly discussing this method and talking with other analysts who have had experience with it, has decided that it can not recommend it this year to be adopted as an official method, but does recommend that it be continued as a provisional method, and that further investigation be made of it. This is the volumetric method, either the Kilgore or McDonnell modification.

Discussion arose as to whether "provisional" or "optional" were meant in this recommendation. Mr. Van Slyke read the note inserted in the "Methods," page 13, on this point.

The President. Would it not clear up all misunderstanding if the Chair were allowed to state the recommendation as follows:

That the committee recommends that the volumetric method remain stated, as heretofore, as a provisional method, and it be recommended for further study.

Mr. Wheeler. A number of members of the association have stated that they have tried this method and abandoned it, being unable to get good results. Other members have obtained at times good results, and at other times poor results. Others claim they have obtained uniformly good results. It seems to me that so long as there are so many who obtain poor results at times or have had to give it up, it would be unwise for this association to adopt it until it has been further studied and shown to be reliable in the hands of the average analyst.

Mr. **Scovell.** I think none of us wants to adopt a method that would not give uniformly good results on all phosphates. I would hate to go into court and say I had analyzed a fertilizer by a method I was not certain of for high percentages. Both Mr. Peter and Mr. Curtis were much in favor of this method, and they put in a month's solid work. But they failed with it. They could not trust it in high percentages, although it worked very well on low percentages. They tried it very carefully, but it did not always bring good results. I believe the cause is this, that the precipitate is not uniformly of the same composition, and I think we will have to study out some method by which the yellow precipitate will be of uniform composition. Until that is done I do not think we can use the volumetric method and get theoretical results every time. It would be unwise for this association to adopt it as an official method, although it may be adopted as a provisional method, and it is very worthy of further investigation.

Mr. **Kilgore.** The method is certainly much more rapid than the old gravimetric one, but I fully agree with Mr. Scovell in his remarks as to its adoption. In the case of this and every other method I should very much prefer to see that it is thoroughly all right before we put it in the "methods."

The recommendation was thereupon adopted.

Mr. **Bartlett.** The committee recommends that the study of methods of analysis for Thomas slag be continued.

Mr. **Huston.** I would like to inquire whether this recommendation is for phosphates alone, or for complete analysis, which is a very different thing. I do not know what the committee had in mind, but I hope it was complete analysis rather than simply examination for total phosphoric acid.

The **President.** The Chair would rule that it is not intended in this case to confine the referee or the association to this particular line of work (phosphoric acid).

The recommendation was thereupon adopted.

Mr. **Wiley.** While I am far from believing in the so called Wagner method as the only and sole method for analysis, it is evident that we can get comparative results by it. Would it not be well for the association to recommend it as a provisional method while this study is going on, in case it is called upon to examine these slags officially, as it may be before another year? If these slags come on the market before another meeting, any or all of our members may be brought into contact with them officially, and in that case a provisional method recommended by this association would be the only thing they could rely upon.

The **President.** The committee will take that matter into consideration and report upon it.

Mr. Huston. I would like to say a word on this subject. I suppose we are after the available phosphoric acid in this slag. First, have we any evidence whatever in any slag upon which any of the members of this association have worked that there is more than one compound of phosphoric acid present? Is there more than one kind of phosphoric acid in it? Is that phosphoric acid combined with 4 molecules of lime, or is there some other form than what I suppose we will have to call the ortho-phosphoric acid at present? It seems to me that all the methods which we have or have considered simply take out a part of the phosphoric acid. They do not distinguish between phosphoric acid combined with 4 molecules of lime and any other form. This is particularly true of our present official method with neutral citrate. If our official citrate solution be merely diluted and 100 cc put in 100 cc of water, and 2 grams treated with it, very much more phosphoric acid will be dissolved from this slag. If half a gram be used, a still larger per cent will be dissolved. In fact, this is true for any phosphate outside of any material like hard rock. I think it is very largely a question of volume, and, to some extent, of the quantity of reagent used. In examining some slags, two of which were the association's samples, to see if it were possible to work out any scheme by which we could tell how much of this tetrabasic phosphate is present, I have run down some slags, and if my theory in the matter be right all the phosphorus in them is present as the tetrabasic compound. If this be so, I do not see why the part which the citrate happened to miss is not just as good as the part which the citrate did dissolve, the trouble there being simply that we did not use enough volume or did not use fluid enough to keep the resultant product in solution.

So I believe we ought to exercise a little care about adopting the method. I realize, of course, that the Wagner method may give higher results than the official method, but, notwithstanding the fact that they are said to approximate agricultural results, I think we ought to be a little slow about adopting a method for the examination of these slags. I think it would be far safer at present, with the limited amount of slag that there will be on our market and the very uncertain character of it as it may come from some of the works, either to adopt the total phosphoric acid as the standard, or at least put it beside the other. Neither, as I understand it, is to be the official method.

Mr. Lindsey. I want to call attention to the fact that Wagner has made a great many experiments regarding the availability of slag on various kinds of agricultural plants, and he has shown that it has a certain degree of availability. Although I have not given his method critical study, yet my impression is that it corresponds very well with actual results which he got from plant experiments. If we are going to approve a method for determining the availability of phosphoric acid in material of that kind, I believe Wagner's method is better adapted than anything else that has been provided, and it seems to me wise that we should adopt that method provisionally until something better is offered.

Mr. **Wheeler**. The important point to consider is that we are liable to have European slag placed upon our market before the close of this year. There is much surplus slag in Europe, and they are anxious to bring it over here. If it be analyzed by our citrate method, which we have to use under present circumstances, it seems to me the farmers of this country will be led to think that it is less valuable for agricultural purposes than it really is. The Wagner method shows a higher percentage of available phosphoric acid and comes nearer to agreeing with actual experiments on plants, and there is no reason why we should throw a wet blanket on this most excellent material. For that reason it would seem to me much better for the association to use this method.

The **President**. If there be no further remarks, the matter will be considered as referred to the committee on recommendations.

Mr. **McDonnell**. Before we leave this question I think the methods for determining iron and aluminum ought also to be referred to the referee on phosphoric acid for next year. I make a motion to that effect.

Mr. Kilgore moved that it be referred to the committee on recommendations. Adopted.

Mr. Bartlett stated that the committee on recommendations was anxious to finish its work, and if in order, would complete its recommendations on phosphoric acid with regard to basic slag.

Mr. Lindsey's motion that the report be heard was carried.

Mr. **Bartlett**. This recommendation refers to the determination of phosphoric acid in basic slag. The committee recommends that a description of the Wagner method be inserted in the "Methods" as a provisional method for determining phosphoric acid in basic slag. Adopted.

Mr. **Huston**. I wish to urge members to work a little more on slags. The method calls for a certain fixed temperature, I believe 15° or 17°. I have learned from some workers who come here that they find this temperature of the Wagner method either impossible or very inconvenient, and that they have departed from it. This fact may have prevented others from working on it, and I wanted to say that in basic slag the question of temperature is practically nothing. If you will recall what I told you last year, you will see that basic slag differs radically from nearly every other known phosphate in that it makes very little difference what temperature you use, from 4° to 80°, so if any of you have been prevented from taking up the work by the requirements of temperature, I will say that the question of temperature has practically no bearing on the value of the work which you may do.

The report of the committee on recommendations was then called for.

Mr. **Bartlett**. The third recommendation of the committee is:

> In regard to the determination of iron and aluminum the committee recommends that methods for the determination of these substances in basic slag be further investigated.

Mr. Scovell. I think it was the intention that the recommendation cover iron and aluminum in phosphates. I move that the report of the committee be so amended.

The amendment was adopted.

The President. The question is now upon the motion as amended, that the study of iron and aluminum in basic slags and phosphates in general be continued.

The recommendation was adopted.

Mr. Huston. What action was taken in regard to the Wagner method for slags? My recollection is that it was decided to publish the method, in order that all might have an opportunity to try it if they wished. The most conspicuous reason given for publishing the Wagner method is that it gives higher available than our official method. Now, that is not a good reason. I do not think it is the main reason. The main reason is that it has been extensively used in Europe, and it is said that it approximately follows the results derived from plant or pot experiments in the use of this material. It is a matter of great importance where we publish that method. I think we ought to be very careful not to put it in the official methods of the bulletin, but in the volume of the proceedings. If you get it inside the covers of the "Methods," labeled an official method, you will never get it out, and you will have no end of trouble with people who have slag to sell. It is much easier not to put it in than it is to get it out. I wish to guard the matter carefully. If there be any intention to put it among our official methods, we had better put it where it will be easily accessible, but do not let it be supposed that we have given it our official sanction.

It was moved and seconded that the action taken with reference to the Wagner method be reconsidered. Carried, and the matter referred to the committee on recommendations.

Mr. Persons asked for a definition of "optional" and "provisional," as applied to methods.

The President. The word provisional, as contrasted with optional, has this meaning: That the association is not prepared to recommend officially a method as official, but that in the absence of any method with which it is satisfied it suggests this as one which may be used for the purpose. A member uses it on his own responsibility. It is not regarded as an official method.

Mr. Bartlett. The committee recommends that a description of the Wagner method for the determination of phosphoric acid in basic slag be inserted in the proceedings of the association, and that a note be inserted in the "Methods of Analysis," under the head of "Phosphoric acid," to the effect that the Wagner method may be found on page 72 of the said proceedings.

Mr. Huston. I think it would be well to make it "the Wagner method for determining the citrate soluble," and I move to amend to that effect.

The amendment was seconded.

Mr. Lindsey. That is, merely publish it in the proceedings as Wagner's citrate soluble method; not as an official or provisional method. Do I therefore understand that we shall proceed with slags to use the official method, namely, ammonium citrate solution, for the determination of the available phosphoric acid in slags? Do I understand that to be the sense of this meeting?

The President. In Bulletin No. 46 the general statement is, "Method for the examination of fertilizers," and under "Determination of phosphoric acid" there is nothing said with reference to the source of that phosphoric acid, indicating that basic slag is not included. In that case it would seem that the official method would remain the same as before.

Mr. Huston thought this would depend largely upon the ruling of the statutes under which chemists operated. In his own State the statute says, "soluble and reverted phosphoric acid." Each must study the statute in his State and determine what sort of ruling he can make upon it.

Mr. Lindsey. I want to protest against the official method, whether you call it soluble or available or reverted, for determining the soluble and available phosphoric acid in Thomas slag.

Mr. Huston. If you look at last year's proceedings you will find that you can use either solution and get identical results if you will modify the treatment somewhat. Our official solution can be made to do just as the Wagner solution. It is not in the solution; it is in the handling of it. I am not in favor of using either one at present on Thomas slag. I have done a great deal of work, which I did not see fit to report, in investigating whether all phosphoric acid in certain slags is in the form of actual tetrabasic phosphates. If it is, I am convinced it should all have the same valuation. Moreover, our climatic and soil conditions are so different that I do not think we should take any steps toward adopting anything which is based upon climatic conditions in Europe.

The recommendation was adopted and the method is given here. (The amendment seems to have been lost sight of.)

WAGNER METHOD FOR THE DETERMINATION OF PHOSPHORIC ACID IN SLAGS.

(Principles and Practice of Agricultural Analysis, Vol. II, pp. 78-80.)

Solutions employed—Ammonium citrate.—In 1 liter there should be exactly 150 grams of citric acid and 27.93 grams of ammonia, equivalent to 23 grams of nitrogen. The following example illustrates the preparation of 10 liters of the solution: In 2 liters of water and 3½ liters of 8 per cent ammonia, 1,500 grams of citric acid are dissolved, and the cooled solution made up exactly to 8 liters. Dilute 25 cc of this solution to 250 cc and treat 25 cc of this with 3 grams of calcined magnesia and distill into 40 cc of half normal sulphuric acid. Suppose the ammonia nitrogen found correspond to 20 cc of fourth normal soda lye. Then in the 8 liters are contained $\frac{20.0 \times 0.0035 \times 8000}{2.5} = 224$ grams of ammonia nitrogen. Then in order to secure in the 10 liters the proper quantity of ammonia there must be added 2 liters of water containing 230—224=6 grams of nitrogen, or 7.3 grams ammonia; viz, 94 cc of 0.967 specific gravity.

Molybdate solution.—Dissolve 125 grams of molybdic acid in dilute 2.5 per cent ammonia, avoiding a large excess of the solvent. Add 400 grams of ammonium nitrate, dilute with water to 1 liter, and pour the solution into 1 liter of nitric acid of 1.19 specific gravity. Allow the preparation to stand for twenty-four hours at 35° and filter.

Magnesia mixture.—Dissolve 110 grams of pure crystallized magnesium chlorid and 140 grams of ammonium chlorid in 700 cc of 8 per cent ammonia and 1,300 cc of water. Allow to stand several days and filter.

The directions for determining the phosphoric acid in slags and raw phosphates soluble in citrate solutions are as follows:

Five grams of the material, as it is sent into commerce without grinding or sifting, are placed in a half-liter flask and covered with nearly a quarter liter of water, and then 200 cc of citrate solution added, prepared as described above. The flask is filled to the mark with water. The flasks are closed with rubber stoppers and without delay placed for half an hour in Wagner's shaking apparatus. On removal from the apparatus the mixture is filtered and 50 cc thereof treated with double the quantity of molybdic solution at 80°, and the precipitate separated after cooling. The precipitate is carefully washed with 1 per cent nitric-acid mixture, after which the filter is broken and the precipitate washed into a beaker with 2 per cent ammonia and the filter washed therewith until about 100 cc have been used. If the solution be turbid from the presence of silicic acid, it should be precipitated a second time by addition of molybdic solution until the acid reaction is restored. The ammoniacal solution of the yellow precipitate is treated, drop by drop, with constant stirring, with 15 cc of magnesia mixture, and set aside for two hours. The precipitate is collected, washed, ignited, and weighed in the usual manner. The direct precipitation of the phosphoric acid by the magnesia solution in presence of citrate is not advisable, because of the almost general presence of silicic acid, which would cause the results to be too high.

The chair at this point introduced C. E. Munroe, dean of the Graduate School of Columbian University, who welcomed the members of the association to the university and made a cordial tender of its facilities.

Mr. Ewell exhibited and explained a piece of apparatus he had devised for the determination of nitrogen by a modification of the Schultze-Tiemann method.

The chair called for the report of the referee on soils and ash (Professor Goss). The report was read by Mr. Wiley, as follows:

REPORT ON SOILS AND ASH.

By Arthur Goss, *Referee*, and Harry Snyder, *Associate Referee.*

As the first step in the soil work this year, the following circular letter was sent out to the chemists of all the experiment stations of the United States and to such others as it was thought might be interested in the work:

Mesilla Park, N. Mex., *February 16, 1896.*

Dear Sir: The referees on soils and ash for the A. O. A. C. would be very much pleased to have you take part in the work this year.

In accordance with the instructions given the referee by the association at the last meeting, the following points will be taken up in the soil work:

(1) A further study of the N/5 HCl method, outlined in last year's proceedings of the A. O. A. C., for the determination of available phosphoric acid.

(2) A study of the calcium and ammonium chlorid methods, suggested last year, for the determination of available potash.

The above methods gave some very promising results last year, and it is thought that the work this year may be of considerable interest.

(3) A study of the nitrogen contents of the humus as a means of determining the availability of nitrogen.

(4) In additon to the above it has been thought desirable to call for a determination of total potash, phosphoric acid, and nitrogen in the samples, for the purpose of comparison with the presumably available found.

Through the kindness of Mr. H. W. Wiley and Sir Joseph Henry Gilbert, arrangements have been made by which samples of some of the Rothamsted soils will be secured for this work. The samples will be distributed from Washington.

The ash sample will be of a native New Mexico plant of common occurrence. It is hoped that the ash work this year may lead to some much needed changes in the methods of analysis.

Working directions will be sent to those who take part in the work.

Kindly notify the referee if you desire the samples.

Very respectfully,

ARTHUR GOSS, *Referee.*
HARRY SNYDER, *Associate Referee.*

"Regrets" were received from a considerable number of chemists, and requests for samples from the following: H. A. Huston, Lafayette, Ind.; Harry Snyder, St. Anthony Park, Minn.; G. L. Teller, Fayetteville, Ark.; F. W. Traphagen, Bozeman, Mont.; W. R. Perkins, Agricultural College, Miss.; F. W. Woll, Madison, Wis.; H. B. Battle, Raleigh, N. C.; C. G. Hopkins, Urbana, Ill.; A. D. Selby, Wooster, Ohio; J. A. Widtsoe, Logan, Utah; H. B. Hardin, Clemson College, S. C.; E. F. Ladd, Fargo, N. D.; G. C. Caldwell, Ithaca, N. Y.; Elton Fulmer, Pullman, Wash.; A. L. Emery, San Francisco, Cal.; Arthur Goss, Mesilla Park, N. Mex.; F. T. Shutt, Ottawa, Canada.

Upon the arrival of the soil samples from England samples were sent to each of the chemists requesting the same, accompanied by the following working directions:

DIRECTIONS FOR WORK ON THE A. O. A. C. SOIL AND ASH SAMPLES FOR 1897.

THE SOIL SAMPLES.

Should you not find time to complete all the work outlined below, kindly report such results as you may secure.

Test all reagents used by running blank determinations with at least the quantities used in the regular determinations.

Calculate all results to the water-free basis.

(*1*) *Litmus-paper test.*—Test the reaction of the soil with litmus paper. See Eighth Annual Report of the Rhode Island Experiment Station, pages 232 to 280.

(*2*) *Determination of moisture.*—Use the official method, page 38, Bulletin No. 46, Division of Chemistry, United States Department of Agriculture.

(*3*) *Determination of phosphoric acid by treatment with N/5 HCl.*—Prepare a N/5 solution of HCl by titrating against a standard KOH solution containing little or no carbonate. Use phenolphthalein as the indicator.

(*a*) Digest 20 grams of soil with 200 cc of the N/5 acid in a water bath kept at 40° C. for exactly five hours. Filter off the solution through a dry paper until clear, and titrate 20 cc of the filtrate with standard carbonate-free KOH solution, using phenolphthalein as the indicator. From the data thus secured calculate the amount of HCl necessary to be added so that the solution may be N/5, after allowing for the acid neutralized.

(*b*) Transfer 100 grams of the soil to a half-gallon glass-stoppered bottle or other similar vessel, and add exactly 1,000 cc of N/5 HCl, corrected for neutralization as in (*a*). (See last year's Proceedings.) Place bottle in a large water bath (a metal washtub will answer) and keep at a temperature of 40° C. for exactly five hours, shaking thoroughly each half hour. At the end of the digestion shake contents of bottle well and pour quickly upon a large, dry, ribbed filter of two thicknesses of paper and of sufficient size to receive the entire contents of the bottle. The filtrate is to be received in a dry vessel and the solution poured back through the paper until entirely free from soil particles. Evaporate 500 cc of the filtrate to dryness in a porcelain dish after adding a few cc of nitric acid to oxidize organic matter, moisten the residue with HCl, take up with water, and filter into a flask of about 450 cc capacity. Add 15 grams of ammonium nitrate in solution, add strong ammonia until a permanent precipitate forms, and then concentrated HNO_3, until the precipitate dissolves. Dilute the solution to about 100 cc if not already to that volume, heat to 85° C., add 75 cc of recently prepared molybdate solution, digest in a water bath at 80° for fifteen minutes, with occasional shakings, and continue the determination as given in Bulletin No. 43 of the Division of Chemistry, United States Department of Agriculture, pages 58 to 60.

(4) *Determination of potash by treatment with alkaline ammonium chlorid* (*Huston*).—Make up an N/20 solution of ammonium hydrate by titrating against standard acid, using cochineal as the indicator, and dissolve 10.68 grams of c. p. crystalline NH_4Cl in each liter of the same.

Digest 100 grams of soil with 1,000 cc of this solvent exactly as under (1). Evaporate 500 cc of the filtrate to a small volume in a porcelain dish, transfer to a good-sized platinum dish, add one-half cc of concentrated H_2SO_4, and finish the evaporation over the water bath. Heat in the air bath at 140° to 150° C. until danger from popping is past, ignite off the ammonium salts and organic matter, and continue the determination by the Lindo-Gladding method.

(5) *Determination of potash by treatment with N/5 $CaCl_2$ solution.*—Prepare an N/5 solution of $CaCl_2$ by dissolving the c. p. salt in distilled water and titrating against standard $AgNO_3$ solution, using potassium chromate as the indicator.

Digest 100 grams of soil with 1,000 cc of this solvent for five hours at 40°, exactly as under (1). Evaporate 500 cc of the filtrate to dryness in a porcelain dish after adding a few cc of HCl and HNO_3. Take up with water, add ammonium hydrate to alkaline reaction, and precipitate lime, etc., with ammonium carbonate and oxalate. Filter, add one-half cc of concentrated H_2SO_4 to the filtrate, and evaporate to dryness in a large platinum dish. Thoroughly dry in the air bath at 140° to 150° C. to prevent popping, ignite off the ammonium salts, and continue the determination by the Lindo-Gladding method.

(6) *Determination of humus.*—Weigh out either 5 or 10 grams of soil into a 200 cc wide-mouth glass-stoppered bottle. Add 150 cc of a 1 per cent solution of HCl. If the soil contain more than 1 per cent of CaO, then a 2 per cent solution of HCl may be used. Place the stopper in the bottle and shake vigorously. After allowing the acid to act on the soil for five or ten hours the solution is decanted into a filter, a fresh quantity of 100 cc of acid is added, and after about two hours action it is also decanted and the contents of the bottle transferred to the funnel. The soil in the funnel is washed with the dilute acid until no reaction for CaO is obtained, and then with distilled water until the washings are only slightly turbid with $AgNO_3$. After receiving the above treatment the soil is transferred from the funnel to the stoppered bottle, using 150 cc of a 3 per cent solution of ammonia. The bottle containing the soil and ammonia solution is occasionally shaken, and after eight or ten hours the solution is decanted into a 500 cc measuring flask. A fresh quantity of 100 cc of ammonia is added to the soil in the wide-mouth bottle, and after acting on the soil for three or four hours it is decanted and added to the first extract. After the third extraction the extract usually becomes nearly colorless. After the fourth extraction the extract of the humus solution in the flask is made up to 500 cc, and shaken well. After allowing about an hour for the contents of the flask to settle, a 50 cc portion of the filtered humus extract is evaporated to dryness in a tared platinum dish. After drying in either an air or water bath, preferably an air bath at 101° or 102° (on account of the tenacity with which the humus retains water), the dish with the humus materials is weighed, then ignited and weighed again, the loss of weight being calculated as humus.

(7) *Nitrogen content of the humus.*—First treat 5 or 10 grams of soil with dilute HCl in the same way as for the humus determination, then extract the soil with a 3 per cent solution of NaOH in the same way as the ammonia extraction. Two hundred cc of the filtered solution are evaporated nearly to dryness in a Kjeldahl distillation flask, after first making the solution acid with H_2SO_4. The remainder of the acid is added, and the nitrogen determination is completed in the usual way.

(8) *Determination of total nitrogen.*—Use the method outlined on page 2 of Circular No. 2, Chemical Division, United States Department of Agriculture.

Nitrates are not to be included.

(9) *Determination of total phosphoric acid.*—Use the method outlined on page 6 of Circular No. 2, Chemical Division, United States Department of Agriculture. Also see bulletins of the Division of Chemistry, United States Department of Agriculture, No. 43, pages 58 to 60, and No. 47, pages 50 to 57.

(10) *Determination of total potash.*—Use the J. Lawrence Smith method given in Crook's Select Methods, second edition, pages 28 to 40.

The ash sample.—The ash is of Tornillo wood (*Prosopsis pubescens*, Benth).

Analyze by the association method. See Bulletin No. 46, Chemical Division, United States Department of Agriculture, pages 43 to 45.

Please report suggestions as to changes in the methods of analysis.

Respectfully,

ARTHUR GOSS, *Referee.*
HARRY SNYDER, *Associate Referee.*

Up to date the following results on the soil samples have been received:

TABLE NO. 1.—*Soil samples. Results calculated water-free.*

Analysts.	Sample No. 1.—Gilbert mark W3. Wheat continuously for 53 years without any manure.							
	Reaction with litmus paper.	Per cent of moisture.	Per cent of acid neutralized by preliminary digestion.	Per cent total N, official method.	Per cent total N, HgO omitted.	Per cent humus.	Per cent N in humus, with 3 per cent NaOH.	Per cent N in humus, with 3 per cent KOH.
C. C. Moore, U. S. Dept. Agr			41.5			2.30		
T. C. Trescot, U. S. Dept. Agr				0.09			1.00	
A. M. Peter, Ky		1.66	43.7					
L. M. Bloomfield, Ohio		1.56		.11		3.29	2.64	
John Thompson, S. C	Neutral.	1.41		.12		1.47	4.92	
Elton Fulmer, Wash		1.65						
J. F. Moore, Ark		1.75						
Harry Snyder, Minn				.094	0.088	1.58	3.17	3.17
R. F. Hare, N. M	Alkaline.	1.59	45.2	.10				
Arthur Goss, N. M	Alkaline.		44.2					
Average	Alkaline.	1.60	43.7	.102	.088	2.16	2.93	3.17

Analysts.	Sample No. 2.—Gilbert mark B2A. Fertilized for 53 years with 200 pounds ammonium salts and 350 pounds superphosphate per annum.							
	Reaction with litmus paper.	Per cent moisture.	Per cent acid neutralized by preliminary digestion.	Per cent total N, official method.	Per cent total N, HgO omitted.	Per cent humus.	Per cent N in humus, with 3 per cent NaOH.	Per cent N in humus, with 3 per cent KOH.
C. C. Moore, U. S. Dept. Agr			38.5			2.19		
T. C. Trescot, U. S. Dept. Agr				0.10			1.10	
A. M. Peter, Ky		1.78	34.5					
L. M. Bloomfield, Ohio		1.68		.12		2.93	2.41	
John Thompson, S. C	Neutral.	1.65		.12		2.38	3.14	
Elton Fulmer, Wash		1.88						
J. F. Moore, Ark		2.03						
Harry Snyder, Minn				.104	0.095	1.82	3.00	3.00
R. F. Hare, N. M	Alkaline.	1.87	35.7	.11				
Arthur Goss, N. M	Alkaline.		35.1					
Average	Alkaline.	1.81	35.9	.110	.095	2.33	2.41	3.00

TABLE NO. 2.—*Soil samples—Results calculated water-free.*

Analysts.	Sample No. 1.—Gilbert mark W 3. Wheat continuously for 53 years without any manure.									
	Per cent total P_2O_5. Goss method.	Per cent total P_2O_5. Five hours' digestion with HNO_3.	Per cent P_2O_5 with N/5 HCl.	Per cent P_2O_5 with N/5 HNO_3.	Per cent total K_2O. Smith method.	Per cent total K_2O with HFl.	Per cent K_2O with N/5 NH_4Cl.	Per cent K_2O with N/5 $CaCl_2$.	Per cent K_2O with N/5 HCl.	Per cent. K_2O with N/5 HNO_3.
C. C. Moore, U. S. Dept. Agr	0.13	......	[1]0.008	......	1.21	......	0.012	0.014	......	......
A. M. Peter, Ky	......	......	[3].004	[3]0.003	......	......	.008	.006	0.019	0.019
L. M. Bloomfield, Ohio	.10	......	.003	......	.97	......	.017	.020	......	......
John Thompson, S. C	[1].03	......	.006	......	1.42	1.38	.010	.007	......	......
Elton Fulmer, Wash	......	......	.002	......	......	......	......	[1].029	......	......
J. F. Moore, Ark	.12	......	.003	......	......	......	......	.008	......	......
Harry Snyder, Minn	.12	[2]0.12	.004	......	......	......	......	......	......	......
R. F. Hare, N. M	.13	......	......	......	......	......	......	......	......	......
Arthur Goss, N. M	.11	......	.005	......	......	......	......	......	......	......
Average	.118	.12	.0039	.003	1.20	1.38	.0118	.0110	.019	.019

Analysts.	Sample No. 2.—Gilbert mark B2A. Fertilized for 53 years with 200 pounds ammonium salts and 350 pounds superphosphate per annum.									
	Per cent total P_2O_5. Goss method.	Per cent total P_2O_5. Five hours' digestion with HNO_3.	Per cent P_2O_5 with N/5 HCl.	Per cent P_2O_5 with N/5 HNO_3.	Per cent total K_2O. Smith method.	Per cent total K_2O with HFl.	Per cent K_2O with N/5 NH_4Cl.	Per cent K_2O with N/5 $CaCl_2$.	Per cent K_2O with N/5 HCl.	Per cent K_2O with N/5 HNO_3.
C. C. Moore, U. S. Dept. Agr	0.20	......	0.033	......	1.08	......	0.009	0.012	......	......
A. M. Peter, Ky	......	......	[3].036	[3]0.029	......	......	.005	.003	0.016	0.017
L. M. Bloomfield, Ohio	.21	......	[1].027	......	1.45	......	.020	.013	......	......
John Thompson, S. C	[1].09	......	.037	......	1.35	1.30	.009	.005	......	......
Elton Fulmer, Wash	......	......	[1].054	......	......	......	.051	.020	......	......
J. F. Moore, Ark	.18	......	.038	......	......	......	......	.005	......	......
Harry Snyder, Minn	.16	[2]0.16	.033	......	......	......	......	......	......	......
R. F. Hare, N. M	.18	......	......	......	......	......	......	......	......	......
Arthur Goss, N. M	.17	......	.037	......	......	......	......	......	......	......
Average	.183	.16	.0357	.029	1.29	1.30	.0188	.0097	.016	.017

[1] Not included in the average.

[2] Molybdate precipitate made at 65°.

[3] Molybdate precipitate made at 40° in four hours.

For the phosphoric acid and nitrogen work, the soil samples sent out were probably the best that could have been secured. The great length of time that the Rothamsted experiments have been in progress has made the field data with which to compare the analytical results thoroughly reliable.

For the potash work, it would have been better to have sent out another sample, which had been fertilized with potash, to be used in connection with No. 1, which has received no fertilizer. Neither of the samples sent out has received any potash during the last fifty-three years of continuous cropping. This point was discovered by the referee too late to be rectified; so about all that has been secured this year in the potash work is a comparison of results. In order that the results of this year may be made more valuable, it would probably be well to send out one of the Rothamsted samples next year that has been fertilized with potash salts.

It was thought by the referees that more could be accomplished by dividing the work. Mr. Snyder very kindly consented to take charge of the nitrogen work, and to him credit for the same should be given. He makes the following comments upon that part of the work:

> There is only a very slight difference in the total nitrogen content of the two soils. A marked difference could not be expected because there has been no residual nitrogen to be added to the total nitrogen originally present in the soil. The ammonium salts not utilized by the crops, according to the Rothamsted reports, have never accumulated in the soil for the succeeding crops. Our results are in accord with this fact. A marked difference in the amount of humus in these two soils could not be expected, because humus-forming manures have not been used. The nitrification and oxidation of the humus in these two soils during the successive years of cultivation have undoubtedly been quite uniform. Soil No. 2, although it has received an annual dressing of ammonium salts, is, according to the results, deficient in nitrogen. This is in accord with the field results, because remunerative crops can not be obtained without the continued use of ammonium salts on the plot. On this point the field results and analytical results agree. The per cent of nitrogen in the humus from both plots is low—much lower than the amount usually found in soils that are well stocked with available nitrogen.
>
> The humus results of the different analysts do not agree as closely as they should. This is partially due to an imperfection in the method, which can undoubtedly be remedied—that is, obtaining a clear filtrate with the ammonia treatment. If a clear filtrate is not obtained, hydrated clay-like particles are present in the humus residue when it is ignited, which gives too high results. I do not think the humus methods have been tried by a sufficient number of analysts to entitle them to a place as official methods. The results are encouraging, and with improvements in the methods, and their application to a greater variety of soils known to be deficient, and well supplied with available nitrogen, a safer conclusion can be reached regarding their value.

It may also be added that the results on total nitrogen agree very well, and seem to indicate that the association method for that determination is now about all that could be desired.

Undoubtedly one of the most important features of the work this year has been that on the availability of phosphoric acid as determined by treatment with N/5 HCl. The difference between the two soils has been brought out in a very striking manner by this solvent. In every case the results agree with the known facts in saying that sample No. 2 has a much larger amount of available phosphoric acid than No. 1. With one or two exceptions, the results by the different analysts agree very well—quite as well in fact as could be expected with a new method.

Sample No. 2 having received 350 pounds of superphosphate per annum for more than fifty years, would naturally be expected to contain considerably more available phosphoric acid than No. 1, as the amount applied has been greatly in excess of the amount removed by the crops. There has, in fact, been so much added that the difference is seen in the totals. In every case a larger amount of total phosphoric acid has been found in No. 2 than in No. 1. It will be observed, however, that the dilute acid very much magnified the difference in phosphoric acid content between the two soils. While the ratio between the average totals from the two soils is 1 to 1.55, the corresponding ratio from the N/5 acid is 1 to 9.16.

As a further check on the N/5 HCl method, through the kindness of Mr. Wiley and Sir J. H. Gilbert, samples from a number of the Rothamsted Broadbalk wheat-field plots were secured, and both the total phosphoric acid and that soluble in N/5 HCl determined.

The results secured are given in Table No. 3.

TABLE NO. 3.—*Results calculated water free.*

[Rothamsted soil samples—Broadbalk wheat field.]

No phosphates added for 53 years.					Fertilized with 350 pounds superphosphate per annum for 53 years.				
Gilbert mark.	Reaction with litmus paper.	Per cent moisture (five hours).	Per cent total P_2O_5 (Goss method).	Per cent P_2O_5 with N/5 HCl.	Gilbert mark.	Reaction with litmus paper.	Per cent moisture (five hours).	Per cent total P_2O_5 (Goss method).	Per cent P_2O_5 with N/5 HCl.
W3	Alkaline	1.59	0.11	0.005	B4A	Alkaline	1.63	0.19	0.034
B3A	Alkaline	1.43	.11	.003	B2A	Alkaline	1.87	.17	.037
B1A	Alkaline	1.81	.11	.002	W11	Alkaline	1.77	.18	.043
W10A ...	Alkaline	1.75	.10	.004	W13	Alkaline	1.82	.19	.045
Av ..	....	1.65	.108	.0035	Av ..	....	1.77	.183	.0398

By referring to the table it will be seen that the analytical results check with the known facts in every instance. While there is, in every case, a difference in amount of total phosphoric acid between the plats receiving phosphatic fertilizers and those not receiving the same, this difference is greatly magnified in the results secured with the N/5 acid. The ratio between the average totals is 1 to 1.7, while the corresponding ratio for the N/5 HCl is 1 to 11.4.

Through the kindness of Messrs. Frear and Armsby, two composite samples from the Pennsylvania Experiment Station fertilizer plats were also secured. These samples were analyzed in the same way as the Rothamsted samples recorded in Table No. 3. The results secured are given in Table No. 4.

TABLE NO. 4.—*Results calculated water free.*

[Pennsylvania Experiment Station. Soil samples from Tier I, general fertilizer series.]

Sample I.—From plats 1, 8, 14, 24, 36. No fertilizer added for 16 years.				Sample II.—From plats 11, 21. A total of 384 pounds phosphoric acid per acre added in 16 years.			
Reaction with litmus paper.	Per cent moisture (five hours).	Per cent total P_2O_5 (Goss method).	Per cent P_2O_5 with N/5 HCl.	Reaction with litmus paper.	Per cent moisture (five hours).	Per cent total P_2O_5 (Goss method).	Per cent P_2O_5 with N/5 HCl.
Neutral............	1.12	0.09	0.0046	Neutral...........	1.35	0.13	0.0084

Dr. Frear states that the unfertilized plats have been proved deficient in available phosphoric acid, as adjacent plats have responded quite freely to the application of phosphates. By referring to the table, it will be seen that but a small amount of phosphoric acid was secured from the sample from the unfertilized plats, an amount about the same as that secured from the Rothamsted plats receiving no phosphates, while nearly twice as much was obtained from the plats which had received 384 pounds of phosphoric acid per acre in sixteen years. This, it appears to me, is again in accordance with the facts in the case. It will be noted that only a comparatively small amount of phosphoric acid was added to the fertilized plats, an amount equal to but 24 pounds per acre per annum. It is no doubt true that a considerable portion of this was removed in the increased crops secured by the use of the complete fertilizer employed, so that one would not expect a very great increase of available phosphoric acid in the sixteen years that the experiments have been in progress.

The above evidence, added to that secured last year, would, it seems to me, justify us in strongly recommending the N/5 HCl method for phosphoric acid for adoption as an official method of the association.

There are one or two points in the method as it stands at present, however, that should be changed before it is adopted.

Mr. Peter has called attention to the fact that all of us who have worked with the samples this year have doubtless observed that the final precipitate from the soil deficient in phosphoric acid is extremely small. This necessitates exceptionally careful work to avoid error. While this precipitate is still many times larger than the gold bead secured in the ordinary gold assay, still I agree with Mr. Peter in thinking that it would be conducive to more uniform results to increase the size of the precipitate by increasing the amount of the soil taken in the case of soils thought to be low in available phosphoric acid, and shall therefore make that recommendation.

It has been thought by one or two that the short time allowed in the method for the formation of the yellow precipitate is not sufficient, in the case of such small amounts of phosphoric acid as are present in soils deficient in that substance. While the referee very strongly believes the contrary, based on results from a large number of experiments, conducted for the purpose of settling that point, a considerable number of which has been reported in the A. O. A. C. proceedings in the past, still, as it can do little harm for the yellow precipitate to stand longer than ten minutes at 80°, it might be well to make the directions read: Allow to stand not less than ten minutes after removing from the 80° bath. This will permit those who have doubts on the above point to allow the precipitation to proceed over night if desired.

In the preliminary digestion to determine the amount of acid neutralized by the soil, it is quite unnecessary to take as much as 20 grams of soil and 200 cc of acid. Half these amounts is ample.

Mr. Moore, of the United States Department of Agriculture, seems to have mistaken the intention of the referee in that instead of increasing the strength of the N/5 acid sufficiently to allow for the acid neutralized by the soil and keeping the volume the same, he secured the increased amount of acid by taking a larger volume of N/5 acid. This point should perhaps be a little more definitely brought out in the directions. It seems to the referee to be more conducive to concordant results to use the same volume of solution in each case.

By having a large stock solution of normal or half normal HCl on hand, it is very little trouble to calculate the number of cubic centimeters of the same and the number of cubic centimeters of water necessary to be used to make a liter of acid of the desired strength. For the preliminary digestion all that is necessary is the N/2HCl used by many in the nitrogen work, which same can be very readily diluted to make N/5 acid.

Mr. Peter did some valuable experimenting on the samples this year other than that called for in the directions. This work will be found recorded in Tables Nos. 1 and 2. Among other things he showed that N/5 nitric acid gave results quite as good on these soils as N/5 HCl, and in some ways he thought it might be preferable to HCl.

In regard to the other determinations made in the soil samples, perhaps all the information that is necessary concerning them can be secured by referring to Tables Nos. 1 and 2.

THE ASH SAMPLE.

The results secured on the ash sample are given in Table No. 5.

TABLE No. 5.—*Ash of tornillo wood* (*Prosopis pubescens*).

Substances.	J. K. Haywood, U. S. Dept. of Agr.	G. L. Teller. Arkansas.	A. M. Holt, New Mexico.	L. M. Bloomfield, Ohio.	Average.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Soluble SiO_2	11.12	10.73	....	7.37	9.74
Insoluble SiO_2 (sand)	10.29	11.16	....	14.70	12.05
Total SiO_2	21.41	21.89	21.40	22.07	21.69
K_2O	11.05	11.03	11.03	11.35	11.11
Na_2O	3.57	3.87	4 32	6.89	4.66
CaO	35.55	35.10	34.57	34.46	34.92
MgO	8.97	7.18	6.92	8.12	7.80
Mn_3O_4	.24	.23	.27	.48	.30
Fe_2O_3	....	1.00	....	....	....
Al_2O_3	....	2.28	....	....	....
$Fe_2O_3Al_2O_3$	1.35	(3.28)	3.32	.97	2.23
P_2O_5	3.28	3.39	3.46	3.45	3.40
SO_3	.67	.66	.87	.59	.70
CO_2	12.75	12.28	12.49	....	12.51
Cl	.26	.60	.22	.23	.33
C	.78	.67	1.51	.88	.96
Moisture	.22	....	.18	....	.20
Total	100.10	100.18	100.56	....	....
O equivalent of Cl	.06	.13	.05	....	....
Corrected total	100.04	100.05	100.51	....	....

It will be seen by referring to the table that the agreement of results on several of the determinations is very good. There are other determinations, however, on which the agreement is not so good as could be wished. This is particularly true in the case of soluble and insoluble silica, iron, aluminum, and soda.

As the methods for the proposed separation of soluble and insoluble silica have been shown to be utterly unreliable (see Proceedings of the Eleventh Convention of the A. O. A. C., pp. 43, 44), and as this separation is, to say the least, of very doubtful utility, it would seem to be well to combine the soluble and insoluble silica determinations in one of total silica. This would shorten the work and result in more uniform results. This, then, will be offered as a recommendation.

The way the method for potash and soda stands at present, if literally followed, may not result in a complete separation of the alkali chlorids from lime, etc. The referee believes that both ammonium carbonate and oxalate should be used in precipitating out the lime, etc., and that the process of purification will in some cases have to be carried even further than called for in the directions. This will constitute another recommendation.

In the New Mexico laboratory it has been found impossible to secure reliable results in the determination of chlorin by the volumetric method, notwithstanding the fact that we constantly employ that method in the analysis of waters, and should be familiar with the same. The end reaction in the case of ash solutions is frequently so indistinct that the exact point can not be told with any degree of certainty. On the other hand, the gravimetric method has been found to give perfectly reliable results. The referee therefore thinks that the volumetric method for chlorin in ash should be stricken out and the gravimetric method required.

RECOMMENDATIONS.

The referee this year wishes to leave as clear a field as possible for his successor, and has therefore only one recommendation to make in regard to the work that shall be taken up next year, and that is:

(1) That the ammonium and calcium chlorid methods be tried again next year on the Rothamsted samples Nos. 16069, Gilbert mark W 10A, and 16070, Gilbert mark W 13, if Mr. Wiley have sufficient of the same. No. 16069 has been in wheat continuously for fifty-three years and fertilized annually with ammonium salts equivalent to 86 pounds of nitrogen per acre. No. 16070 has been in wheat continuously for the same length of time and fertilized annually with 400 pounds of ammonium salts, 350 pounds superphosphate, and 200 pounds sulphate of potash.

(2) It is recommended that the N/5 HCl method for available phosphoric acid, in the form given below, be adopted as an official method of the association.

Determination of phosphoric acid soluble in N/5 HCl.

(*a*) Prepare a large stock solution of normal HCl by titrating against a standard KOH solution containing little or no carbonate, using phenolphthalein as the indicator.

(*b*) Digest 10 grams of air-dried soil, in a stoppered flask, with 100 cc of N/5 HCl, for exactly five hours in a water bath kept at a temperature of 40° C. Filter off the solution through a dry paper, cool to the room temperature, and titrate 20 cc of the filtrate with standard carbonate-free KOH solution, using phenolphthalein as the indicator. From the data thus secured, calculate the exact number of cubic centimeters of normal acid from the stock solution and of water to combine to make exactly one or two liters of acid of N/5 strength after allowing for the amount neutralized by the amount of soil to be taken in (*c*).

(*c*) Transfer 200 grams of the air-dried soil to a large, dry, glass-stoppered bottle or other similar vessel, and add exactly 2,000 cc of N/5 HCl corrected for neutralization as in (*b*). (In the case of soils known to be rich in available phosphoric acid 100 grams of soil and 1,000 cc of acid will be sufficient.) Place the bottle in a large water bath (a metal washtub is excellent) and keep at a temperature of 40° C. for exactly five hours, shaking thoroughly each half hour. At the end of the digestion shake contents of bottle well and pour quickly upon a large, dry, ribbed filter of two thicknesses of paper and of sufficient size to receive the entire contents of the bottle. The filtrate is to be received in a dry vessel and the solution poured back through the paper until entirely free from soil particles. Evaporate 1,000 cc of the filtrate if 200 grams of soil were taken, or 500 cc if 100 grams were taken, to dryness in a porcelain dish, after adding a few cubic centimeters of nitric acid to oxidize organic matter, etc., moisten the residue with HCl, take up with water, and filter into a flask of about 500 cc capacity. Add 15 grams of ammonium nitrate in solution, add strong ammonia until a permanent precipitate forms, and then concentrated nitric acid until the precipitate dissolves. Dilute the solution to about 100 cc, if not already to that volume, place a thermometer in the flask, and heat to exactly 85° C. Add 75 cc of recently prepared molybdate solution, digest in a water bath at 80° for fifteen minutes, with occasional shakings, remove from the bath and allow to stand at least ten minutes before filtering. Continue the determination as given in Bulletin No. 43 of the Division of Chemistry, United States Department of Agriculture, pages 58 to 60.

(3) It is recommended that in the third line from the bottom, first paragraph under "Analysis of the ash," Bulletin No. 46, Chemical Division, United States Department of Agriculture, page 44, the words "an S. & S. hardened filter" be stricken out and the words "a tared Gooch crucible" be substituted instead. Further, that section (*a*) be changed to read as follows:

(*a*) *Determination of carbon and silica.*—The carbon and silica in the Gooch crucible are to be dried at 120° C. to constant weight, incinerated to constant weight, and the amount of carbon determined from the loss in weight.

(4) That on page 45, in the fourth and seventh lines from the top, the words "and ammonium oxalate" be inserted after "ammonium carbonate," and that at the end of the paragraph the following be added: "Test the purity of the chlorids by dissolving same in a few cubic centimeters of water and adding a few drops of ammonium

carbonate and oxalate solution. If a precipitate occur, or if there be an insoluble residue upon dissolving in water the same must be filtered off, the solution evaporated to dryness, ignited, and reweighed. In any case the ammonium salts must, of course, be ignited off before the potash determination is made."

(5) That section (*f*) be changed to read as follows:

(*f*) *Determination of Chlorin.*—Boil 10 grams of the ash in 400 cc of pure water for half an hour, transfer to a measuring flask of 500 cc capacity; cool, make up to volume, filter off through a dry folded paper, transfer 100 cc of the filtrate to a beaker, acidify with nitric acid, heat to boiling, add silver nitrate solution in excess, and stir vigorously until the precipitate collects. Filter off the precipitate through a tared Gooch crucible, wash thoroughly with hot water, dry at 110°, and weigh the AgCl secured.

CONCLUSION.

In conclusion the referee wishes to thank those who have taken part in the work this year for their cooperation, and to state that he believes the association will agree in saying that the subject of soil analysis is another step forward as a result of the year's work. To his successor he would say, Let the good work proceed.

Mr. Wiley read a letter from Mr. Caldwell, expressing regret at not being able to be present. He also read a letter from the referee on sugar, stating that owing to illness in his family he could neither be present nor prepare a report.

REMARKS OF SECRETARY WILSON.

The Chair at this point introduced the honorable Secretary of Agriculture, who had just entered the hall. The Secretary was greeted with applause. He said:

MR. PRESIDENT AND GENTLEMEN: I have merely stopped in to add to your welcome to the capital city of the nation. I am glad to see you. As a representative of the farming classes of the country, I am proud to say in your presence that we recognize fully the necessity of the chemist in all advances that are being made along lines of progress in agriculture. I need only mention briefly the work being done all along the line.

In dairy matters we have Babcock and Patrick, who have helped the farmer to better methods and enabled the American farmer to put his products on the markets of the world and compete successfully with dairy production of the famed countries of Europe. The chemist has helped us to do this. I might mention the work being done along the line of making the United States independent of other countries in sugar. The work being done by many of our experiment stations along this line is of great value. A hundred million dollars is hung up within reach of the American farmer, and the chemist is telling him how to get it, analyzing his beets, and telling him what soils are best for his purposes. Permit me to assure you that the retention of this hundred million dollars among our people will be due in great part to the excellent work being done by the chemist. I mention these things only to show the appreciation of your work by those who till the soil. As regards the light in which we estimate you here, I stand ready to make good whatever Dr. Wiley wants done by the Department of Agriculture. (Applause.)

I have but one ambition here that I very greatly desire to have gratified during my short stay in connection with the Department of Agriculture. If I can succeed, through the help of the corps of scientists connected with the Department, in impressing future Presidents of the United States with the fact that no man should be Secretary of Agriculture without a scientific knowledge of agriculture, then my ambition will have been satisfied. No matter what the political complexion of the President of the United States who may succeed the present occupant of the White House, I would like to have him select for Secretary of Agriculture a man who understands not only the practical but the scientific side of agriculture. I think this may possibly be done if we succeed fairly well in impressing the country that the work we are doing is good, honest, helpful work now.

I thank you for your attention, and will detain you no longer. It is a serious thing to interrupt scientific gentlemen, even for a moment. (Applause.)

The Chair expressed the gratification of the association at the Secretary's remarks.

Mr. Wiley read a letter from Professor Hilgard, calling attention to a paper, on the objects and methods of soil analysis, read at the Minneapolis meeting of the Association of Agricultural Colleges and Experiment Stations:

THE OBJECTS AND METHODS OF SOIL ANALYSIS.

Paper of E. W. Hilgard, read before the Detroit meeting of the Society for the Promotion of Agricultural Science.

Among the recommendations made to the Association of Official Agricultural Chemists by the referee for 1896 (Professor Goss) the first reads as follows:

"That the complete analysis of a strong acid solution of the soil, as given last year and in preceding years, be stricken out of the official methods of the association."

In the referee's record of work preceding these recommendations he shows a keen insight and presents so many new and important facts regarding the action of root solvents upon soils and the variety of causes that may influence their action that I can not but express surprise and regret at the recommendation above quoted. It appears to me to tend in the direction of narrowing down the function of the agricultural chemist to that of a mere analyst, dependent upon figures alone—the very state of things which has contributed most to the discredit so long attaching to chemical soil analysis. As the same referee has been reappointed for 1897, and will be sure to carry out the recommendations as adopted with the same ability manifested heretofore, I desire to interpose a demurrer against the argument upon which he bases the above recommendation.

Especially on the ground that potash, phosphoric acid, and nitrogen are the only three elements needed to be supplied in fertilizers, Goss argues that these are the only ones required to be determined by the analyst as to their total quantity and availability. "Practical analysis of the soil," he says, "should tell us with reasonable certainty the amount and availability of these three substances as present in the soil, and then we will have accomplished the principal thing that is at present demanded of the soil analyst." He admits that it is interesting, from a scientific point of view, to know something of the other ingredients, and that they may have some bearing on plant production; but thinks that the time required for their determination could be better used for other purposes.

But what does Goss mean by "practical analysis?" The word "practical" has been much abused in connection with agricultural science and practice. It is launched against us as a kind of thunderbolt, both by the men who wholly disbelieve in the application of science to agriculture, as well as by the politician, who tries to make capital by denouncing our agricultural experiment stations for pursuing any line of research which does not appear to him to bear directly upon the operations of the farm. Now, if in "practical analysis" Goss speaks only with reference to satisfying the demands of the public, I must dissent from him as to the propriety of attempting to conciliate these two classes at the expense of the true objects and methods of investigation, for which our stations were established. Such concessions are not only directly harmful to the true purposes of station work, but indirectly lead only to further inadmissible demands on the part of the self-styled practical man.

While, as I have always insisted, the stations ought assuredly first to cater to the pressing needs of the population by their work, yet they will be untrue to their mission if they fail to develop at the same time agricultural science from its scientific side, and thereby aid in enabling it to enlarge its functions beyond the mere prediction of the present productive capacity of land and its immediate needs in fertilization. But even as regards fertilization, it is quite obvious that the kind of fertilizers to be used should depend in very many cases essentially upon the presence or absence of other ingredients than the three furnished in the fertilizers. From the latter point of view, Goss's recommendation is not well advised, even if only meant to apply to the commercial chemist who does not go beyond the supplying of figures to his client, leaving the latter to interpret them for himself as best he may. It is not enough that his figures should show that nitrogen, phosphoric acid, or potash are deficient or abundant, but it must also be shown what, from the general character of the soil, is the *form* in which these substances should be supplied, and in what manner. The chemist should, for instance, be able to tell the farmer whether his soil is such that the application of a superphosphate to the surface will, in the ordinary course of events, assure a supply of that substance to the roots of his crops; or whether, e. g., the presence of an excess of calcic carbonate will prevent the penetration of the superphosphate to the depth of not more than an inch or so; or whether, as in the highly ferruginous soils of Hawaii, any water-soluble phosphoric acid will, in a short time, be definitely locked up in the insoluble form, so that, instead of a superphosphate, it should be applied in the form of phosphate slag, or in that of di-calcic phosphate. Speaking quite generally, the presence or absence of lime is, and has long been known to be, such a potent determining factor in the producing qualities of soils, that the proposition to omit its determination as a part of the regular. analysis for practical purposes will sound strangely in the ears of agricultural chemists the world over. It means that it is of no practical consequence to know whether a soil is naturally marled already or requires artificial marling to improve its chemical or physical condition, or both; whether it is naturally adapted to the production of leguminous crops, and a score of other points which are everywhere considered of importance to the farmer.

Similarly in the case of potash, it is not a matter of indifference whether or not a large proportion of zeolotic silicates is present, by which it may be retained, or whether the next rain may wash it through the soil beyond the reach of the roots. From this point of view alone, then, the determination of lime, iron, and "soluble" silica are of direct importance, even according to the present imperfect state of our knowledge. But how shall that knowledge ever be perfected if the recommendation of the referee as to the determination of the three ingredients alone should be accepted by our experiment station workers? It seems to me that the very fact quoted by Goss that "we know but little about the relation of these substances to vegetable nutrition" should lead him to reverse his conclusions, at least so far as the experiment station work is concerned.

The recommendation works the wrong way also in the case of virgin soils; for in the case of cultivated land something at least is usually known in a general way regarding the character of the soil and the main points to be observed in their treatment. As I have frequently urged, in virgin soils the proportion of actually available plant food may ordinarily be presumed to be proportionate to the total amounts present as ascertained by the usual methods of analysis; so that the determination of actually available plant food by the method of Dyer or others becomes for the time being unnecessary. But it is of the greatest importance to know whether such soils are, for instance, sufficiently or highly calcareous or not, since that indicates from the outset not only their adaptability or nonadaptability to certain important cultures, but also the sufficiency of their potash supply. In the case of ferruginous soils again, it is of the highest importance to inform the farmer that if he allow the subsoil to become swamped by an overuse of irrigation water or otherwise, that subsoil will become not only useless but positively poisonous, not only to roots within it, but also to those some distance above it, because of the reduction of ferric hydrate to ferrous carbonate, or other ferrous salts. In irrigation regions it is often of paramount importance that this should be known beforehand.

I contend, therefore, that the determination of lime, ferric oxid, and soluble silica is of such general importance, not only with a view to the general qualities of the soil under cultivation, but also with reference to the use of fertilizers, that to omit these determinations and to restrict soil analysis to the "practical" determination of potash, phosphoric acid, and nitrogen, is inadmissible as tending to lead to erroneous inferences, not only theoretically, but practically.

But if these determinations be made, it is difficult to see wherein the process of general analysis as heretofore practiced can be materially abridged. It is true that we might omit the determination of the alumina, determining only the iron by titration of the solution of the joint precipitate. But this is a very trifling abridgment and prevents the comparison of the amount of soluble silica with that of alumina with reference to kaolinite, which, as I have heretofore shown, frequently goes to prove the presence of free aluminum hydroxid in the soil. It is true that we do not know the exact significance of this substance in connection with the soil functions, but it is certainly desirable that we should obtain this knowledge hereafter; and to omit this determination for the sake of so slight a saving of time seems to me to be a deviation from the principles of sound investigation, of which certainly the stations should not furnish the example.

As regards other substances, viz, magnesium and manganese, I agree that manganese might very well be let go in with iron, if this were compatible with the proper separation from the lime; for, so far as we know, manganese exerts little or no influence upon vegetable nutrition, and its functions in the soil appear to be of no special significance. But it is quite otherwise with magnesia. It is of the utmost importance, next, probably, to lime; its functions in the soil may or may not be restricted to the neutralization of acid, and therefore the prevention of acidity, and the formation of the zeolitic silicates. But so long as it is omnipresent—and frequently in very large proportions—it seems highly expedient, from the standpoint of general scientific investigation, to make its determination an invariable practice. We have no method of separating potash from it without so close an approach to its actual gravimetric determination that, as in the case of alumina, it seems almost wantonness to omit to weigh it for the sake of so slight a saving of time. If we were to adopt the method of Grandeau, which precipitates potash by perchloric acid from a complex solution, there would be better reason for urging the abandonment of the determination of magnesia. Again, if the abridgment of labor be the point so essentially desired, I am at a loss to see the propriety of substituting in the determination of the total phosphoric acid the sulphuric acid method of Goss for the one with nitric acid, as heretofore practiced. There is no question that the sulphuric-acid method requires much more time and attention on the part of the operator, and it is liable to a number of accidents from which the nitric-acid method is entirely free. The only claim it can make for consideration is that it extracts the phosphoric acid more completely in case of the presence of highly insoluble compounds, such as crystallized vivanite and other phosphate minerals. But it may be seriously questioned whether the presence of such minerals in the soil is of any "practical" use whatever. I question that it is even of theoretical interest to the investigator of soils from the agricultural standpoint, however interesting from that of the geologist or mineralogist. As in the case of the use of sulphuric acid for the determination of alumina in soils, it leads to an overestimate of the soil's capacity to supply the ingredient sought. It stands on a similar plane of utility as the determination of potash by means of hydrofluoric acid, which, so far as I can see, is totally devoid of interest from an agricultural standpoint. It is not reasonably to be supposed that any organic acid, not even oxalic, to the dilution in which it is applied by the plant is likely within any time in which we are interested to go beyond the action of strong hot nitric acid. I do not think that Goss has presented any reasons for abandoning the nitric acid digestion as a method of determining the phosphoric acid in soils sufficient to justify the substitution therefor of his very thorough and ingenious but troublesome and excessively incisive method. When I find in Hawaiian soils that yield to the Dyer solvent only 0.004 of P_2O_5 by the nitric-acid method nearly 1 per cent, it is certainly of no practical interest to me to know that HCl will take out of the same soil nearly twice the amount that nitric acid did. Nor will it be of any practical interest to obtain still more by means of the Goss sulphuric-acid method.

The most important step in advance shown by Goss's report, and for which if confirmed by further experience the agricultural world will be grateful to him, is the substitution of dilute HCl for the determination of available potash and phosphoric acid instead of the organic acids heretofore used. While I must say that within my own experience thus far the citric-acid solution has given excellent results whenever the neutralization of carbonate of lime and magnesia in the soil has previously been properly observed so as to render the solvent of uniform strength, yet the much greater facility with which HCl may be used in analytical operations renders its use so desirable that it must be earnestly hoped it will prove as much of a success as now seems probable. The remarkable effect of calcium chlorid, however, causes me to suggest that the effect of neutralization would in the case of HCl be quite different from that of citric acid so far as potash is concerned; for in many cases the amount of calcium chlorid formed by neutralization will greatly exceed in its effects that of the HCl itself, and it would therefore seem that as a general reagent for the determination of available potash the latter is unavailable for the great majority of soils.

The convention then adjourned until 2 p. m.

WEDNESDAY—AFTERNOON SESSION.

ELECTION OF OFFICERS.

The committee on nominations presented the following report:

The committee on nominations begs to present the following names for the several elective offices of the association:

For president, Mr. A. L. Winton, of Connecticut; for vice-president, Mr. R. C. Kedzie, of Michigan; for secretary, Mr. H. W. Wiley, of Washington, D. C.; for members of the executive committee, Mr. M. A. Scovell, of Kentucky, and Mr. J. L. Hills, of Vermont.

C. L. Penny,
L. L. Van Slyke,
Elton Fulmer,
Committee on Nominations.

Upon motion the report was accepted.

Mr. Bigelow moved that the Chair be instructed to cast the ballot of the association for the officers nominated. Carried, and the officers named declared duly elected.

VISIT TO DEPARTMENT OF AGRICULTURE.

The PRESIDENT. The regular order of business is to proceed to the Department of Agriculture, as arranged. Before doing so, however, I desire to name the committee to confer with the committee from the Association of Agricultural Colleges and Experiment Stations on the subject of fertilizers. In the appointments I have tried to secure as wide representation of the different sections of the country as possible, and name as the committee to represent this association Messrs. Wiley, of Washington, D. C.; Kilgore, of Mississippi; Huston, of Indiana; McDonnell, of Maryland, and Ross, of Alabama.

The convention thereupon adjourned to visit the Department of Agriculture.

The members of the association visited first the chemical laboratory, where they inspected the methods of sugar-beet analysis and the polarimetric room. The methods of mounting and adjusting the standard instruments and of illuminating their scales were studied. The operation of the bomb calorimeter for the combustion of bodies in a compressed atmosphere of oxygen was illustrated. The members then proceeded to the office of the Secretary of Agriculture and were most cordially received by the Secretary in his office.

THIRD DAY.

THURSDAY—MORNING SESSION.

Called to order at 9.30. No member of the committee on recommendations being present, the regular order was postponed and the Chair called for the report on foods and feeding stuffs.

Mr. Lindsey read the report, as follows:

REPORT ON CATTLE FEEDS.

By J. B. Lindsey.

I.

Estimation of Starch.

Among the so-called standard methods for the estimation of starch may be mentioned those of Sachsse, Märcker, Reinke, Asboth, Guichard, Baudry, and the diastase methods. Most of these methods give fairly concordant results when the substance examined contains no other carbohydrates than pure starch. Stone[1] has shown, however, that when the most of these methods are employed on materials containing a variety of carbohydrates, very different starch percentages result. Sachsse's method, which consists in boiling the substance directly with dilute hydrochloric acid, is recommended by the Association of Official Agricultural Chemists for use only in estimating the starch content of commercial starch and potatoes. The other methods which have seemed best adapted for the estimation of starch in agricultural products, are the diastase and the Märcker methods; also the Märcker method as modified by Reinke.

A year ago your referee compared the diastase and Märcker methods without securing any very decisive results, consequently both were adopted by the A. O. A. C. as provisional methods until further investigations could be made.

The work on starch this year consisted in comparing the diastase, Märcker, and salicylic-acid or Baudry modified methods on three different substances. Our principal object in testing the Märcker method was to note whether heating for one-half hour, under 3 atmospheres in one-tenth of 1 per cent tartaric-acid solution, would exert any solvent action on carbohydrates other than starch. The Reinke modification of the Märcker method consists in omitting the diastase treatment, using one-half of 1 per cent lactic acid, and in heating for two and one-half hours under 3½ atmospheres. We preferred to test the original Märcker method, feeling sure that the Reinke modification would have a greater solvent action than the method originally brought forward by Märcker. The methods as sent out were described as follows:

I. DIASTASE METHOD.

Exhaust 3 to 5 grams of substance with ether, and treat the residue in a beaker with 50 cc of 10 per cent alcohol for one-half hour with frequent stirrings, filter, and wash with strong alcohol. Bring the dried residue into a beaker with 50 cc of water, immerse beaker in a boiling-water bath, stirring contents constantly until all the starch gelatinizes; cool to 55° C., add 20 cc of malt extract, and maintain at this temperature until the solution no longer gives the starch reaction with iodin. Filter into a 10-ounce flask, wash until the filtrate amounts to 200 cc, add 20 cc of 25 per cent hydrochloric acid (sp. gr. 1.125), connect with a reflux condenser and heat in a boiling-water bath for two hours, cool, and when lukewarm neutralize carefully with Na_2CO_3 (avoiding excess), and make up to 500 cc. Mix well, pour through a dry filter, and determine dextrose in an aliquot part by Allihn's method. Convert dextrose into starch by the factor 0.9.

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[1] Journal of the American Chemical Society, 16, 726.

II. MÄRCKER'S METHOD.

Free 3 to 5 grams of substance from fat and water soluble material by use of ether and 10 per cent alcohol, as described under diastase method. Dry the residue, powder, and bring into a Linter pressure bottle (if Soxhlet digester is not at hand) with 50 cc of water; immerse bottle in a boiling-water bath until the starch gelatinizes, stirring constantly, cool to 55° C.; add 10 cc of malt extract and maintain at this temperature for one hour. Now add 5 cc of a 1 per cent tartaric acid solution, and heat at 140° C. for one-half hour (or in autoclave at 3 atmospheres one-half hour), or 110° C. for one hour; cool to 55° C.; add 10 cc of malt extract, and maintain at this temperature until the solution no longer gives the starch reaction with iodin. Filter through linen, using suction, into a 10-ounce flask, and wash with water until the filtrate amounts to 200 cc, then add 20 cc of 25 per cent hydrochloric acid and proceed as in the diastase method.

Preparation of malt extract.

Digest 10 grams of fresh, finely ground malt over night at laboratory temperature with 200 cc of water, and filter. Determine the amount of dextrose in a given quantity of the filtrate by boiling with acid, etc., as in the determination of starch.

III. BAUDRY MODIFIED OR SALICYLIC ACID METHOD.

Free 3 to 5 grams of substance from fat and water soluble material as already described. Bring the dried and pulverized residue into a beaker with 100 cc of water, in which is dissolved ½ gram salicylic acid, and heat the beaker in a boiling water bath with constant stirring, until the starch is rendered soluble (10 to 15 minutes). Now filter quickly through linen, using suction, wash with hot water to the volume of 200 cc, add 20 cc of 25 per cent hydrochloric acid, and proceed as under the diastase method.

Some time after the samples necessary for testing these three methods were sent out, Mr. H. W. Wiley kindly sent, at our request, a description of a method employed in his laboratory for the estimation of starch. We compared this with the other three methods.

IV. WILEY'S METHOD.

Extract the fat from 3 grams of the material, dry the residue and digest for two and one-half hours, at 3½ atmospheres, in an autoclave, with ½ gram salicylic acid and 50 cc of water. After cooling, make up to 250 cc, filter, and invert 200 cc of the filtrate in a 500 cc flask with 15 cc of hydrochloric acid (sp. gr. 1.125) for two and one-half hours at 100° C. Neutralize exactly with sodium carbonate, cool, make up to 500 cc, and determine the dextrose in 25 cc by Allihn's method.

The three samples sent out were corn meal, wheat middlings, and lupine seeds, each ground sufficiently fine to pass a ½ mm sieve. The corn meal contained no other known carbohydrate than starch, excepting small amounts of cellulose. The wheat middlings contained, in addition to a moderate amount of starch, liberal quantities of pentosans. The lupine was known to contain pentosans and galactan—both hemicelluloses—in addition to very small or questionable amounts of starch. The presence of starch alone in one substance, of starch and pentosans in a second, and of starch, pentosans, and galactan in a third, would certainly present conditions suitable for testing the accuracy of the three methods. We present first the results obtained in our own laboratory.

TABLE I.—*Results with different methods of estimating starch.*

Methods.	Per cent of starch in—		
	Corn meal.	Wheat middlings.	Lupine seed.
Diastase	62.53	19.38	2.11
Märcker	65.54	26.84	14.68
Salicylic	57.02	19.03	6.21
Wiley	68.04	34.00	16.41

It will be observed that both the Märcker and Wiley methods yield higher results than the diastase method. This is exceptionally noticeable in the case of the wheat middlings and lupine, which contain other carbohydrates than starch. The salicylic method gave lower results than the diastase in case of the corn meal, about the same for wheat middlings, and higher for the lupine. We are naturally led to inquire the cause of these differences. It would seem at least possible that one or both of the hemicelluloses had been attacked by the action of the several atmospheric pressures. The data throwing light on this point will be found in Tables II and III.

TABLE II.—*Total pentosans, and pentosans present after starch extractions.*

Substance.	Corn meal.	Wheat middlings.	Lupine seeds.
	Per cent.	*Per cent.*	*Per cent.*
Total pentosans	6.02	20.51	9.94
Pentosans after dilute alcohol treatment	5.69	18.30	9.73
Pentosans after dilute alcohol and diastase treatment	4.97	17.14	8.75
Pentosans after dilute alcohol and Märcker treatment	3.70	12.04	5.58
Pentosans after dilute alcohol and Wiley treatment	.29	1.26	1.38

We first determined the total pentosans in each of the three substances, and also after these substances had been treated with the dilute alcohol solution for the removal of water-soluble carbohydrates. A slight decrease in the pentosan percentages is noted as a result of this preliminary treatment. After corn meal had been subjected to diastase treatment for the removal of the starch, the percentage of pentosans decreased from 5.69 to 4.97, or a percentage loss of 12.6. A considerable length of time (four hours) was required to remove all of the starch from the corn. It is possible that the solvent action of the water at 55° C. was in a measure, or entirely, responsible for this decrease rather than the action of the diastase. The Märcker method caused a decrease of from 5.69 to 3.7, or 35 per cent, while in removing the starch by the Wiley method practically all of the pentosans were also removed. The wheat middlings show a percentage pentosan decrease of 6.3 by the diastase, 34.2 by the Märcker, and 93 by the Wiley method. In case of the lupine, a percentage decrease is noted of 10, 42.7, and 85.8 by the diastase, Märcker, and Wiley methods, respectively.

TABLE III.—*Total galactan, and galactan present after starch extraction.*

Substance.	Lupine seeds.
	Per cent.
Total galactan	14.87
Galactan after dilute alcohol treatment	12.25
Galactan after dilute alcohol and diastase treatment	9.36
Galactan after dilute alcohol and Märcker treatment	1.16
Galactan after dilute alcohol and Wiley treatment	0.33

In case of the lupine, which contained a considerable percentage of galactan, the dilute alcohol treatment was found to remove nearly 18 per cent of the entire amount. Of the remaining quantity, the diastase treatment removed 23.7 per cent and the Märcker and Wiley treatments from 90 to 97 per cent. Galactan, in the lupine at least, seems to yield rather more easily than do the pentosans to the action of the various solutions.

We have then positive reasons for the higher starch percentages yielded by the Märcker and Wiley methods above those obtained with the diastase method. It seems established that the several atmospheric pressures render a considerable portion of these hemicelluloses soluble, or possibly even partially destroy them. The Wiley method acts more severely, because of the increased length of time during which the substances are under pressure.

If the Märcker method act thus on the hemicelluloses, it is safe to assume that the Reinke modification would exert a severer action. In fact, Märcker[1] says: "The Reinke method may give perphaps too high results; but, on the other hand, the Märcker method yields positively too low results." He makes emphatic, however, that "the Reinke method is to be used only for those materials which, during the manufacturing process, are subjected to high pressures; it yields at least 3 per cent too high results for all other conditions." The diastase method is now recommended and used by Märcker for the estimation of starch in fodders. The substances causing the high results in case of the pressure methods he does not state, but simply refers to them as "nicht Stärke," i. e., substances not starch. This, at least, leaves one to assume that the pressure acts partially on the cellulose and partially on other carbohydrates not specified.

In view of the facts presented, we feel bound to condemn for the estimation of starch the Märcker, Reinke, and Wiley methods. It seems probable that any method requiring the substance to be subjected to pressure would be included in this condemnation. The fact is not overlooked, however, that in the diastase method either the diastase or the water exercises a slight solvent action on the hemicelluloses, which probably tends to increase the percentage of true starch. In the following table are given the results obtained by different analysts with the diastase, Märcker and salicylic methods:

TABLE IV.—*Results obtained by other chemists.*

Analysts.	1. Corn meal.			2. Lupine seed.			3. Wheat middlings.		
	Diastase method.	Märcker's method.	Salicylic method.	Diastase method.	Märcker's method.	Salicylic method.	Diastase method.	Märcker's method.	Salicylic method.
	Per ct	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
W. H. Krug, U. S. Dept. of Agr.	69.28	71.34	....	2.58	16.79	....	[1]30.94	[1]35.58	......
O. W. Knight, Me. Exp. Sta.	61.47	....	52.50	None.	....	7.51	[1]15.89	....	19.11
C. D. Howard, N. H. Exp. Sta	65.19	....	....	2.43	....	....	20.46	....	......
C. A. Brown, jr., Penn. Exp. Sta.	67.15	....	62.98	2.40	....	11.63	21.01	....	[1]25.00
C. H. Jones, Vt. Exp. Sta	61.17	....	55.68	1.64	....	1.21	20.14	....	17.00
H. C. Sherman, Columbian Univ.	67.79	68.30	67.68	......	....	....	21.00	24.68	22.18
E. B. Holland, Mass. Exp. Sta	62.53	65.54	57.02	2.11	14.68	6.21	19.38	26.84	19.05
Average	64.94	68.39	59.17	2.23	15.73	....	20.4	25.76	19.3

[1] Excluded from average.

While wide variations occur in the figures presented by different analysts, they, nevertheless, make emphatic the conclusions drawn from our own work. In the results obtained with corn meal, three analysts secured by the disastase method 61.72 per cent of starch, three others 68.07 per cent, and one 65.19 per cent. It is to be confessed that these differences are difficult to explain. The writer endeavored to obtain all of the data necessary for recalculation, but was only partially successful. Very few chemists undertook the Märcker method, not possessing an autoclave. For the corn meal the average results by this method are higher than those obtained by the diastase method, while with the salicylic method the results are lower. In case of the lupine, six analysts employing the diastase method find but very small percentages of starch, while the Märcker method shows 16 per cent. With wheat middlings five chemists employing the diastase method obtained very encouraging results, one too low, and one evidently too high. The Märcker method again yields high figures, while the salicylic acid agrees fairly well with the diastase method.

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[1] Die Agricultur Chemische Versuchsstation Halle: ihre Einrichtung und Thätigkeit, p. 113.

REMARKS.

The differences in the percentage of starch secured by different analysts may be accounted for as follows:

In the description of the method sent out, it was advised to free the substance from water-soluble material by treatment for one-half hour in a beaker with 50 cc of 10 per cent alcohol, stirring frequently. We found later that this method did not seem to remove all of the soluble material, so, in our case, the substance was brought on a filter and washed with 150 cc of 10 per cent alcohol.

Secondly, some analysts might not have correctly calculated the amount of dextrose to be deducted for the malt solution. In the third place, the methods employed for reducing the copper might have caused variations. It is believed a particular method should have been specified. At first we reduced the copper in hydrogen, but experienced some trouble because the metal, on its removal from the stream of hydrogen, after it had become cool, immediately oxidized on the surface and increased in weight. We, therefore, substituted a stream of dry oxygen, and weighed as copper oxid, with highly satisfactory results. A few comparative tests on a 1 per cent solution of pure dextrose gave results in favor of the oxidation method. We propose to still further investigate this point. Again, the substances should have been ground finer. They were all passed through a one-half mm sieve, but we believe they should have been ground to near a powder, in order to allow the diastase to do thorough work.

The salicylic or modified Baudry method has a tendency to give low results when employed on substances containing high starch percentages, because of the difficulty experienced in getting all of the starch into solution. Fine grinding may, in a measure, overcome this difficulty. Again, it is difficult to know how long the hot salicylic acid solution can be left in contact with the substance, because of its tendency to attack both the pentosans and the galactan. (Note the results obtained with the lupine in Table IV.)

RECOMMENDATION.

We recommend that the diastase method be declared the provisional method of the A.O.A.C. for the estimation of starch in all substances, excepting in commercial starch and in potatoes.

Diastase method.

Extract from 2 to 5 grams of the finely powdered substance with ether, bring the extracted residue onto a filter, or into a Gooch crucible, and wash with 150 cc of 10 per cent alcohol, and then with a little strong alcohol. Place the residue in a beaker with 50 cc of water, immerse the beaker in a boiling water bath, and stir constantly until all of the starch is gelatinized; cool to 55° C.; add from 20 to 40 cc of malt, extract and maintain at this temperature until the solution no longer gives the starch reaction without iodin. Cool and make up directly to 250 cc; filter; bring 200 cc of the filtrate into a 10-ounce flask with 20 cc of 25 per cent hydrochloric acid (sp. gr. 1.125); connect with a reflux condenser and heat in a boiling-water bath for two hours; exactly neutralize while hot with sodium carbonate, avoiding excess, and make up to 500 cc. Mix the solution well, pour through a dry filter, and determine the dextrose in an aliquot part by Allihn's method, pages 53-57, No. 46. Convert the dextrose into starch by the factor 0.90.

PERCENTAGES OF PENTOSANS AND GALACTAN IN ORDINARY CATTLE FEEDS.

We desire at this point to call the particular attention of chemists to the very general distribution of the pentosans and to the extent of the galactan in agricultural plants and seeds. If methods where pressure is employed for the determination of starch do render soluble a considerable portion of those other carbohydrates, it is evident that their value must be exceedingly limited. The percentages of pentosans and galactan in various feeds are indicated in the tables given below:

TABLE V—*Pentosans.*

[Partly our own work, partly compiled.]

Cattle feeds.	Per cent.	Cattle feeds.	Per cent.
Hay of various grasses	15–22	Wheat meal	8.78
Hay of salt grasses	24–28	Soy bean meal	5.12
Rye straw	24.84	Wheat bran	15–29
Wheat straw	26.50	Brewers' grains	24–30
Barley straw	24.47	Corn cobs	31.34
Oat straw	24.84	Linseed meals	13.49
Pea straw	17.11	Gluten feed	17.16
Corn stover	15–22	Gluten meal	4.50
Clover hays	11–15	Dried distillery feed (atlas gluten feed)	13
Corn meal	6.02	Rape cake	5-08
Whole oats	15.55	Sugar beets	9–12

TABLE VI.—*Galactan.*

[Determined by E. B. Holland.]

Cattle feeds.	Galactose.	Galactan.	Cattle feeds.	Galactose.	Galactan.
COARSE FODDER.	*Per cent.*	*Per cent.*	CONCENTRATED FEEDS—con'd.	*Per cent.*	*Per cent.*
English hay	1.01	0.91	Green soja bean	0.67	0.60
High grown salt hay	.93	.84	Black soja bean	.92	.83
Black grass	.71	.64	Bush lima bean	.79	.71
Corn stover	.76	.68	Pole lima bean	.66	.59
Oat straw	.81	.73	Black wax bean (dwarf)	.52	.47
Rye straw	.63	.57	White pot bean	.53	.48
Fodder millet	.95	.86	Horse bean	1.83	1.65
Canada beauty pea fodder	3.09	2.78	Canada beauty pea	.63	.57
Medium red clover fodder	3.73	3.36	Prussian blue pea	.75	.68
Alsike clover fodder	4.25	3.33	English gray pea	.84	.76
Mammoth clover fodder	3.77	3.39	Little gem pea	1.16	1.64
CONCENTRATED FEEDS.			Wonder pea	1.62	1.46
Corn meal	.05	.05	Pea meal	2.69	2.42
Wheat meal	.23	.21	Vetch seed	1.17	1.05
Oat meal	.81	.73	Serradilla seed	.66	.59
Barley meal	.55	.50	Medium red clover seed	2.77	2.49
Wheat bran	.43	.39	Mammoth clover seed	3.63	3.27
Millet meal	.67	.60	Crimson clover seed	3.49	3.14
Linseed meal	1.31	1.15	Alsike clover seed	6.96	8 03
Cotton-seed meal	.63	.57	Sweet clover seed	6.00	5 40
Rice meal	1.04	.94	White clover seed	10.08	9.07
Rape seed	1.07	.96	Alfalfa seed	5.23	4.71
Brewers' grain	.56	.50	White lupine seed	13.84	12.46
Malt sprouts	.43	.39	Blue lupine seed	16.29	14.66
Dwarf horticultural bean	.68	.61			

Many of the substances tested show less than 1 per cent of galactan, and we are not certain in many cases, because of the small amount of precipitate obtained, whether the material weighed really was mucic acid or partially decomposed organic matter. All substances, therefore, containing less than 1 per cent of galactan may be for the present characterized as doubtful. To settle the question of the presence or absence of very small amounts of galactan, we shall either be obliged to still further perfect the method or work with larger quantities.

The results as given above show the presence of very small amounts of galactan in the nonleguminous coarse fodders and seeds. In the leguminous plants from 3 to 4 per cent are present, while in case of the leguminous seeds, several varieties of beans and peas appear to contain very limited quantities, but the larger number of such seeds tested shows from 1¼ to as high as 14 per cent. With the exception of the lupines, the clover seeds contain the largest amounts, the seeds of the white variety containing 9 per cent.

The above results are merely a report of progress. They show, however, that the galactans are not so widely distributed nor present in such large quantities as are the pentosans, and therefore do not play such an important part as do the latter in the process of nutrition.

The data in the following table show the relations existing between the known and unknown nitrogen-free matters in some common substances:

Difference between estimated carbohydrates and extract matter.

Substances.	Corn meal.	Middlings.	Lupine.
	Per cent.	*Per cent.*	*Per cent.*
Starch (diastase method)	64.94	20.40	2.23
Pentosans (phloroglucin method)	5.67	19.50	9.54
Galactan	None.	None.	14.87
Total	70.61	39.90	26.64
Extract matter	83.35	58.72	40.38
Soluble carbohydrates and unaccounted for	11.74	18.82	13.74
Allowing for soluble carbohydrates	3.00	3.00	3.00
Still unaccounted for	8.74	15.82	10.74
Percentage of total extract unaccounted for	10.60	26.90	26.60

Stone[1] has already called attention to this fact. Of the cause of this difference we are at present ignorant. A portion of it can possibly be accounted for because of imperfect methods for the estimation of carbohydrates. In materials of a woody nature, containing large amounts of crude fiber, it is known that the action of dilute acid and alkali removes a considerable portion of the lignin acids so that they are reckoned with the extract matter. It seems, however, quite probable that other carbohydrates or similar substances exist, which have not as yet been identified.

ESTIMATION OF PENTOSANS.

Councler[2] has suggested that, instead of phenylhydrazin, phloroglucin be employed for the precipitation and estimation of furfurol obtained by the distillation of various substances, with dilute hydrochloric acid. Kruger and Tollens[3] have further studied and perfected the method, and recommended it as reliable for the estimation of pentosans in various coarse fodders, grains, and vegetables.

The phloroglucin, like the phenylhydrazin method, is based on the fact that the pentosans (araban, xylan, etc.) differ from other carbohydrates in that they yield furfurol instead of levulinic acid, upon digestion with moderately dilute hydrochloric or sulphuric acid. The first step necessary in both processes, for a quantitative estimation, is the conversion of the pentosans into furfurol and its separation from the resulting by-products.

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[1] Journal of Am. Chemical Society, Vol. XIX, 4.

[2] Chemikerztg., 1894, No. 51.

[3] Zeitsch. für ang. Chem., 1896, Heft II.

On account of its greater simplicity, the phloroglucin method is to be preferred. We considered it advisable, therefore, still further to compare the two methods with substances containing different quantities of pentosans.

PHLOROGLUCIN METHOD DESCRIBED.

Three grams of the material are brought into a 10-ounce flask, together with 100 cc of 12 per cent hydrochloric acid (sp. gr., 1.06), and several pieces of recently heated pumice stone. The flask, placed upon wire gauze, is connected with a Liebig condenser, and heat applied, rather gently at first, using a gauze top to distribute the flame, and so regulated as to distill over 30 cc in about ten minutes from the time that boiling begins. The 30 cc driven over are replaced by a like quantity of the dilute acid, by means of a separatory funnel, and the process so continued so long as the distillate gives a pronounced reaction with anilin acetate on filter paper (a few drops of anilin in a little 50 per cent acetic acid). To the completed distillate is gradually added a quantity of phloroglucin[1] dissolved in 12 per cent hydrochloric acid, and the resulting mixture thoroughly stirred. The solution first turns yellow, then green; and very soon an amorphous greenish precipitate appears, which grows rapidly darker till it finally becomes almost black. The solution is made up to 500 cc with 12 per cent hydrochloric acid, and allowed to stand over night. In case there is very little furfurol in the substance tested, and the resulting distillate consequently small, it is best to add sufficient 12 per cent hydrochloric acid to the distillate before adding the phloroglucin solution, so that, upon the addition of the latter solution, the resulting mixture will contain approximately 500 cc.

The amorphous black precipitate is filtered into a tared Gooch crucible through an asbestus felt, washed with 100 cc of water,[2] dried to constant weight by heating three to four hours at 100° C., cooled and weighed, the increase in weight being reckoned as phloroglucid. To calculate the furfurol from the phloroglucid,[3] use the following table:

Calculation of furfurol.

Total weight of phloroglucid obtained.	Divided by, equals furfurol.	Total weight of phloroglucid obtained.	Divided by, equals furfurol.
0.20 gram	1.820	0.34 gram	1.911
0.22 gram	1.839	0.36 gram	1.916
0.24 gram	1.856	0.38 gram	1.919
0.26 gram	1.871	0.40 gram	1.920
0.28 gram	1.884	0.45 gram	1.927
0.30 gram	1.895	0.50 + gram	1.930
0.32 gram	1.904		

Furfurol ÷ by grams substance taken × 1.84 = pentosans.
Furfurol ÷ by grams substance taken × 1.65 = xylan.
Furfurol ÷ by grams substance taken × 2.03 = araban.

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[1] Dissolve twice as much dry phloroglucin as furfurol expected in about 50 cc of 12 per cent hydrochloric acid. Bring the hydrochloric acid into a water bath, and stir thoroughly till the phloroglucin goes into solution.

[2] By allowing the suction pump to work for some time after the filtration is completed, the drying is greatly facilitated.

[3] The phloroglucid is a complex substance, of uncertain formula. It contains 63 to 64 per cent of carbon and from 3.6 to 4.2 per cent of hydrogen. The factors for calculating the amount of furfurol from the phloroglucid were obtained after experimenting with known amounts of pure furfurol and phloroglucin.

PHENYLHYDRAZIN METHOD.

Proceed exactly as in the phloroglucin method until all of the furfurol is distilled over. Pour the combined distillates into a 700 to 800 cc beaker. If the distillates be less than 400 cc, add 10.2 grams of sodium chlorid for each 50 cc less than that volume, and complete the volume with water to 400 cc. Neutralize exactly with sodium carbonate, covering the beaker with a watch glass during the process, and make up to 500 cc; add 10 cc of phenylhydrazin[1] solution, precipitating the furfurol as furfurol hydrazone.[2] Stir thirty minutes, preferably with an automatic stirrer, and filter the solution, using the necessary suction, into a so-called sugar tube about three-quarters inch in diameter and 6 to 7 inches long, drawn out at the lower end and filled with glass wool. Remove the adhering particles with a feather, and do not use over 100 cc of wash water. The drying can be very much hastened by allowing the filter pump to run for some time after the washing has been completed.

Complete the drying in a specially constructed air bath[3] at 55° C. To accomplish this, a partial vacuum is made by drawing air through the tube by aid of a suction pump, the air supply being regulated by pinchcocks. The air before entering the tube is conducted through sulphuric acid to dry it, and through vertical glass tubes containing small pieces of marble, to remove any sulphuric acid that might be carried over mechanically. Cool the tubes in a desiccator and weigh. Dissolve out the precipitate with hot alcohol and reweigh, and consider the loss in weight as furfurol hydrazone.

FACTORS.

Furfurol hydrazone × .516 + .0104 ÷ weight of substance taken = furfurol.
Furfurol × 1.84 = pentosans.
Furfurol × 1.65 = xylan.
Furfurol × 2.03 = araban.

TABLE VII.—*Results of comparative tests.*

Analysts.	1. Corn meal.		2. Lupine seed.		3. Wheat middlings.	
	Phenylhydrazin method.	Phloroglucin method.	Phenylhydrazin method.	Phloroglucin method.	Phenylhydrazin method.	Phloroglucin method.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
W. H. Krug, U. S. Dept. of Agrl	4.78	....	[1]12.23	....	18.19	....
C. D. Howard, N. H. Exp. Stat	....	5.40	....	8.89	....	18.50
	(5.94)	....	(9.91)	....	(19.63)	....
C. A. Brown, Jr., Penn. Exp. Stat	5.11	5.60	9.04	9.80	18.77	19.50
E. B. Holland, Mass. Exp. Stat	4.72	6.02	9.45	9.94	20.23	20.51
Average	4.87	5.67	9.24	9.54	19.06	19.50

[1] Excluded from average.

In corn meal the phloroglucin method gives noticeably higher results. Mr. Wiley reports a similar experience with wheat, securing 5 per cent of pentosans by the phenylhydrazin and 8 per cent by the phloroglucin method. A sample of wheat tested in our laboratory gave 6.90 per cent by the former and 8.78 per cent by the latter method. We are at present unable to account for this difference. Excepting the grains, it can be said that the phloroglucin gives only very slightly higher results than the phenylhydrazin method. Mr. Brown, in Mr. Frear's laboratory, had difficulty in securing a clear filtrate after stirring the phenylhydrazin precipitate for a half hour and filtering. By allowing the filtrate to stand forty-eight hours and then filtering again he secured, after deducting a blank for the decomposition of the phenylhydrazin itself, 0.039 gram, which he assumes to be phenylhydrazin. In the figures inclosed in the above table, he has added this to his original weight, and in making the calculations for pentosans omitted to add 0.0104, as the formula prescribes. It is to be confessed that by this means his results are brought nearer those obtained by the other method, yet because of the way in which the method was made up this would hardly be allowed.

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[1] Twelve grams of recently distilled phenylhydrazin and 7.5 grams of glacial acetic acid filled to 100 cc with water and well shaken.

[2] After the addition of the phenylhydrazin the solution should react only *very slightly* acid. This is very important. If necessary add the required acetic acid.

[3] See Twelfth Report Massachusetts Experiment Station, 1894, p. 188.

RECOMMENDATION.

We recommend the phloroglucin method, as described above, as the provisional method for the estimation of furfurol in agricultural products.

SUGGESTION.

It is suggested that further study be given to these methods, in order to ascertain their apparent lack of agreement when employed for the estimation of pentosans in the grains.

ESTIMATION OF GALACTAN.

For the estimation of galactan the following method is recommended:

Bring 3 grams of the substance into a beaker about 5.5 cm in diameter and 7 cm deep, together with 60 cc of nitric acid of 1.15 specific gravity, and evaporate the solution to exactly one-third of its volume in a water bath at a temperature of 94° to 96° C. After standing twenty-four hours, add 10 cc of water to the precipitate and allow it to stand another twenty-four hours. The mucic acid has in the meantime crystallized, but is mixed with considerable material only partially oxidized by the nitric acid. The solution is therefore filtered, washed with 30 cc of water to remove as much of the nitric acid as possible, and the filter and contents brought back into the beaker. Thirty cc of ammonium carbonate solution, consisting of 1 part ammonium carbonate, 19 parts water, and 1 part strong ammonia are added, and the beaker brought into a water bath and heated gently for fifteen minutes. The ammonium carbonate takes up the mucic acid, forming the soluble mucate of ammonia. The solution is filtered into a platinum or porcelain dish, and the residue thoroughly washed with water to remove all of the mucate of ammonia. The filtrate is evaporated to dryness over a water bath, and 5 cc of nitric acid of 1.15 specific gravity are added, thoroughly stirred and allowed to stand for thirty minutes. The nitric acid decomposes the ammonium mucate, precipitating the mucic acid, which is collected on a tared filter or Gooch crucible, washed with from 10 to 15 cc of water, then with 60 cc of alcohol, and quite a number of times with ether, dried at 100° for a short time, and weighed. The mucic acid multiplied by 1.33 gives galactose, and this multiplied by 0.9 gives galactan.

Papers relating to the analyses of feeding stuffs were called for and the following report was made.

PRELIMINARY REPORT ON THE ESTIMATION OF FAT IN FODDERS AND GREEN MATERIALS.

By B. W. KILGORE.

"Ether extract" is known by all chemists not to represent the true fat in fodders, hays, and green feeding materials. That it would be highly desirable and important to be able to determine pure fat instead of ether extract in this class of substances is also recognized by all who have to do with them in a way where the question of a knowledge of their composition is involved. So far as we know, no method for obtaining pure fat from these materials has yet been worked out. Without going into a consideration of the character of the substances in ether extract other than fat or of their possible value in nutrition; without considering the effect of a method giving pure fat on the large accumulation of data in the past in the analysis of foods and feeding stuffs and in feeding experiments for beef and butter, or what would be the effect of such a method on this class of work in the future; and without mentioning the numerous failures which have been encountered in the course of a study of this subject during the past eighteen months (since March, 1896), or giving the reasons which led to the procedure in the method, I merely propose to make a preliminary statement to the association of the success I have had in working out a method for the estimation of pure fat in the class of materials referred to. Work on this subject is still in progress in our laboratory, and we ask that the matter be left to us until we have had time to perfect the method and obtain sufficient data for a detailed report.

There are two methods of procedure, both giving about the same results, which appear to be quantitative. Most of our work has been done on the soja-bean plant, which gives quite an impure extract, but enough other materials has been experimented upon to make us believe that the methods will be good for all substances.

The first procedure, which gives not the fat but the fatty acids, is briefly as follows:

Extract the material thoroughly with ether or benzine, and afterwards with alcohol if necessary. (Especially with old materials and leguminous plants containing lecithin, alcohol will remove fat which is not soluble in ether or benzine.) Remove the solvent, saponify with alcoholic potash or soda; evaporate the alcohol, take up the soap with hot water, decompose with hydrochloric acid, add some woolly asbestus, and stir to collect the fat; filter and wash with warm water, partially dry on water bath, and extract with carefully fractioned benzine of 30°–50° C. This gives apparently quite pure fatty acids, usually of a slightly yellowish color.

The second procedure is to extract material with benzine through proper amounts of anhydrous copper sulphate, neutral precipitated calcium carbonate, calcium chlorid, or plaster of Paris. These substances hold back the chlorophyll and coloring matter and yield very nice extracts. Some other salts act in the same way as the above, but possess no advantage over them. These salts do not render the coloring matter of plants insoluble in ether.

DISCUSSION OF ESTIMATION OF STARCH.

Mr. Wiley. I have been as much interested in this paper as in anything else that has been presented, not only because I take very particular interest in the question, but because it is the beginning of the themes which are to be the great discussions of this association in the future. We have practically exhausted the subjects of potash, nitrogen, and phosphoric acid. In subsequent years we may make a few amendments in processes, but it is perfectly certain that unless some new discoveries be made in analytical chemistry our methods in these respects are practically fixed, and the future work of the association lies in those lines which have been neglected in the past. This question of food products, is one of the greatest. The discussion of our food materials in their economic uses, as well as their actual composition, is one of the great problems now confronting the agricultural chemists of the world.

You will be struck by this fact, that the method which is recommended by the referee as the one which should be followed as a provisional method is the one which gives almost the widest variations in results in the hands of the analyst. Now, I appreciate the reasons which led the referee to make this recommendation, and I do not think I could have done otherwise than make the same one myself; but at the same time we must admit that, even in the hands of the experienced analyst, the widest results are obtained in the application of this method. Now, the diastase method rests upon the assumption that this ferment will bring into solution all the starch particles. This is a fundamental error to begin with. It may or it may not; usually it does not. In the first place the action of diastase is conditioned by a great many things in the environment—the temperature, the degree of fineness (which is very important), and the character of the diastase itself. We can not all use the same solutions. We have to make them as we use them, and there are differences in malt. The result is that half a dozen men of this association, in buying malt or preparing it themselves, get solutions which are distinctly different in their hydrolytic properties. Here is a fundamental error of the diastase method—that we do not all work with the same materials or reagents. We prescribe our diastase solution to be made according to a certain method, and yet every man who makes it may have a solution of a different strength, although he follows exactly the directions of the referee.

Another thing, there is no way of knowing that the starch is dissolved except by actual examination. I do not believe there is a member here who can take a ground cereal and extract the starch from it by a single treatment with diastase. The only safe way is to take a portion, stain it, and examine with the microscope. If you get a blue color, repeat the treatment with diastase.

Now, with regard to the operation of diastase upon pentosans, I am glad to have the matter brought before the association, because Mr. Krug and I have paid a good deal of attention to it. Mr. Krug has found, as other investigators of the matter have, that the action of diastase upon pentosans is not a very vigorous one, and, as the referee very aptly suggested, it may be due to the water rather than to the diastase. But, at least, of all reagents used for separating starch from its compounds in cereals, diastase acts least vigorously on the pentosan and other insoluble carbohydrate bodies not starch, present. For that reason, it is to be recommended above all other reagents which have been proposed for this purpose. A paper was published not long ago by König, in Germany, claiming that diastase does dissolve large percentages of pentosans, and this theory we subjected to a very careful and critical examination. Mr. Krug found this claim was a mistake; that while diastase did act to a certain extent in dissolving the pentosan bodies present it was to a very limited extent. On the other hand, we found that salicylic acid under certain conditions would dissolve as high as 90 per cent of the pentosans present. So we have modified our method with regard to starch determinations in this way, that inasmuch as all reagents which dissolve starch do dissolve pentosans to a certain extent it is useless to seek for a reagent which will not.

Then the question arises: Should we not pursue a method which will get the starch at once into solution without respect to the action of the reagent on the pentosan bodies? Our modification, therefore, has been to eliminate the slowly acting bodies and take strongly acting bodies like salicylic acid under high pressure, and then, after determining the total copper which is precipitated in this solution, determine the pentosan bodies therein, or the galactan bodies if they have been acted upon, and deduct from the total the sugar equivalent to these bodies.

The question, of course, of the amount of other bodies yielding dextrose from the fiber which may be present has yet to be considered. Nevertheless, we use practically the diastase method in our determinations. We find, as the referee finds, that we can not conscientiously make any other recommendation at the present time, but we simply insist upon the fact that all the starch bodies shall be brought into solution.

Another question is important. The estimation of potash, of phosphoric acid, and of nitrogen is easy, but it is a difficult thing to estimate starch. In the first place, ordinarily the quantity of material acted upon is small and then only a very small aliquot of that material is used, so that we get in the end only 150 to 200 milligrams as representing the total weight of the material. Hence, any errors in manipulation are greatly magnified before the result is reached, and there is no manipulation which the agricultural chemist is called upon to engage in which requires so much skill, delicacy, and care in every detail as the estimation of starch.

Then we have wide differences in the methods of determining copper. One chemist determines it by the volumetric method; another will precipitate and weigh the copper as oxid after ignition; another will, after precipitation of the copper, bring it into solution and precipitate it electrolytically and weigh it as metallic copper. Theoretically, all these methods should yield good results, but it seems to me that in practice we ought to use a uniform method. We have long since abandoned in our laboratory any attempt to estimate copper volumetrically. In the sugar factory, the volumetric method is to be recommended, because it is quick and reasonably accurate for control purposes, but for all such purposes as ours for fixing methods the volumetric method must be absolutely eliminated; that we must accept as true.

With regard to the differences between estimations as oxid of copper and metallic copper, I think experience leads us to prefer in every respect metallic copper, and I believe the association should adopt that as its method. The copper should be deposited electrolytically and weighed as metallic copper. If a great many of these determinations be made it requires very little more time than the other methods I have mentioned. The analyst working through the day and preparing, say, twenty of these solutions, can connect them over night with the current and in the morning will find the copper precipitated. Therefore we strongly recommend this electrolytic method for the determination of copper.

The bodies which yield furfurol on distillation are far from being simple in their composition. Here is another great trouble we experience. We assume that all the furfurol yielded is due to a definite body, araban or xylan. Now that is a great error, I am sure. If all kinds of fibers be treated for pentosan there will be found a certain quantity of pentosan bodies which are dissolved very rapidly by alkaline solution from these bodies. There is another large quantity of substance, the furfurologenes, which is not dissolved at all, or only slowly, by alkaline bodies. Krug has shown that fibers treated for several hours at high pressure with caustic soda of a certain strength contain, still undissolved, large quantities of bodies yielding furfurol. So we have here very great differences in these bodies. Bevan and Cross have called attention to this and have also proposed the name furfuroid bodies for those which are different from araban, xylan, etc. These are probably substances which have different degrees of solubility. Now what is the relation of these bodies to the original amount of furfurol yielded?

We have found this, that there is no unaccounted-for matter, or at least only a trace, in cereals if all the starch and all the furfurol-yielding bodies calculated as xylose be determined. That practically completes the whole of the cereal material. We have in cereals little galactan. We have a certain amount of soluble sugars which pass into solution, mineral salts, organic compounds, phosphorus, sulphur, etc., and a careful estimation of the starch of a cereal by the diastase method, together with a determination of the other ingredients by approved methods, yields practically 100 per cent. Mr. Krug has obtained results, working with the greatest care, on large numbers of cereals, which come almost as near footing up 100 as ordinary mineral analyses. When it comes to the other feeding stuffs and fibers, the presence of this large amount of a furfurol-yielding body not soluble in alkali under high pressure complicates the determination; but I have no doubt when this relation is established, i. e., the furfurol relation to this other class of bodies, this gap will be filled up.

There is one recommendation of the referee which I hope the committee will take into serious consideration, and that is in regard to shortening the time of conversion. It is highly important that the dextrinoid bodies separated in starch determinations be converted into dextrose, because dextrose is the body we determine. Now, while two hours' boiling will be sufficient in most cases, I do not think the additional hour is going to do any harm. If the time be diminished, the liability to error is increased. Of course there is a difference between boiling and heating to the boiling point. At any rate, the conversion must be complete before the dextrose can be determined.

I do not know, Mr. President, of any more important subject than the one which the referee has so admirably brought before us. The statements in his paper demand and should receive the serious consideration of every member of our association. I should like to see more of our members giving their attention to the investigation of these important problems. There is plenty of room for investigation; nobody has preempted the whole field.

Mr. LINDSEY. It has been very gratifying to me to have Mr. Wiley bring up this matter. I realize that my paper is imperfect, since we have not had time to go over all the points we desire to treat. I want to make one explanation, however, and that is, he has suggested in his method, which gives not only starch but also galactans and pentosans, that all these be taken from the total, and from that be taken the amount of pentosans and galactans, and the remainder be called starch. That I can not accept, because I am convinced that by this pressure a portion of the galactan and pentosans is destroyed, so that we can not get them into bodies which will reduce copper. I realize the difficulty of bringing starch into solution by the aid of diastase, yet I am convinced that at present we can get safer results by the diastase method than by any other, when we are attempting to estimate pure starch; and if Mr. Wiley will refer to the table he will find that Mr. Krug (in Table 6, I think) got very similar results with the diastase method and the Märcker method. I can not see how that is possible. You will also notice that in wheat middlings he got 31 per cent with the diastase method and 35 per cent with the Märcker method. I think his diastase must have worked pretty severely in that case. I can not reconcile his figures at all. I believe the diastase method, at the present time, is the safest method.

In describing the diastase method I have recommended that the substance be powdered. I am convinced that in passing it through a millimeter sieve we do not get it as fine as we ought. To get all the starch acted upon by the diastase, the substance should be put into the form of a powder. I do not doubt that the Department of Agriculture got really more starch than we did. But by the ordinary method, as it is recommended by Märcker and others, the statement is: Treat with diastase solution until the substance no longer gives iodin reaction for starch. That we followed out. I believe by grinding it fine we can get more starch. With reference to the methods for precipitation of copper, I think Mr. Wiley is right.

Mr. WILEY. A cereal can be treated by the diastase method until by the ordinary test it gives no starch reaction at all, yet if examined by the microscope it is found that plenty of starch is left. It is because these starch granules are entirely surrounded by proteid and other incrusting matters that they escape solution. This fact led Mr. Krug and myself to try an interesting modification which we think will be of great benefit, and that is to digest previously with pepsin before using the diastase at all. Our attention was called to pepsin by a French chemist, Mr. Lindet, who proposes to estimate starch directly as starch, and, by the way, his method is an excellent one for technical purposes. He digests his cereal with pepsin and then washes on silk cloth, collects the starch, dries and weighs it; and for technical purposes that is the best method. Mr. Krug has tried this method very thoroughly and finds the amount of fiber held by the starch is not very different from the amount of starch which remains in the fiber. It is an excellent technical method and a fairly good analytical one. This suggested to us the previous solution of this proteid matter before applying the diastase.

Mr. LINDSEY. Would it not be wise to digest all the material, everything, with pepsin?

Mr. WILEY. We don't know but it would. We have not gone far enough to say, but our results are very promising.

Mr. Bartlett asked if longer boiling in water would not be effective in getting at the starch.

Mr. WILEY. I think no amount of boiling would separate the starch from this proteid film. While boiling is an excellent thing for most starch granules, it can not reach the trouble we have here. No amount of boiling will disintegrate these granules.

Mr. WINTON. Where only a few determinations are to be made a very good substitute for diastase is ordinary human saliva. This method was suggested by Professor Chittenden, of Yale, who has worked out very carefully the diastatic action of saliva and has given exact instructions for securing its maximum action. I tried this method eight or ten years ago and found the starch was very completely brought into solution. The action was, if anything, quicker than that of diastase. We have no correction for sugar to make in this reagent.

Mr. WILEY. The trouble with saliva is that it is rather difficult to filter. It takes a long time to get it through. Of course, this use of saliva is an old one; we have tried it also, but did not think its activity, except in perfectly free granules, was sufficient. Then we had great difficulty in filtration; even diastase does not filter any better than it should.

Mr. Van Slyke moved to postpone discussion of the next three papers relating to foods until all three had been read. Adopted.

Mr. Kilgore presented informally a preliminary report on some work he had been doing in the estimation of fat. The chair suggested that Mr. Kilgore write up this statement in form for publication in the proceedings, which Mr. Kilgore agreed to do.[1]

Mr. Hills exhibited some blue prints of a mill which he had in use for grinding fodder samples, and described its operation.

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[1] The paper by Mr. Kilgore is found on page 98.

The chair called for the report on food legislation. This was read by Mr. Wiley, as follows:

REPORT ON FOOD LEGISLATION.

To the President and Members of the Association of Official Agricultural Chemists.

GENTLEMEN: Your committee, appointed to consider the subject of pure-food legislation, begs to make the following report:

The importance of a general pure-food law for the District of Columbia and the Territories of the United States, and for foods passing from one State to another, is admitted by all who have devoted any attention to the subject of pure-food legislation. The authority of the National Congress can not go beyond the limits mentioned above. Already the National Legislature has passed a local food law for the District of Columbia, which in many of its provisions would be suitable for general legislation. It is important, however, that a national food law which will apply to the whole country within the limits mentioned above should be typical in character and become a basis upon which the State legislatures might model the local laws for the several States. Not only is it evident that legislation in regard to pure foods, both national and State, is of the utmost importance, but it is also at once evident that there should be a general agreement in the provisions of the laws enacted by the General Government and by the States. Your committee would recommend that this association urge upon Congress the passage of a pure-food law, the essential provisions of which are the same as the Paddock law, which passed the Senate on March 9, 1892, but failed to come to a vote in the House of Representatives. Your committee would recommend a reintroduction of the bill with a few slight modifications which follow in the appended copy.[1] Your committee is of the opinion that a general bill regulating food adulteration would be far more effective than the passage of particular acts, such as those relating to the manufacture and sale of oleomargarine, filled cheese, etc. The whole subject of food adulteration should, in the opinion of your committee, be treated in a broad and scientific spirit by the National Legislature in such a way as to secure the enactment of a law which, in its scope and method of application, could serve as a model for similar laws in all the States.

In conclusion, your committee would recommend that if favorable action be taken upon the report herewith submitted, the same be transmitted to the proper committees of the national House of Representatives and of the Senate, with the indorsement of this association favorable to a speedy action along the lines mentioned.

Respectfully,

H. W. WILEY.
H. A. HUSTON.
A. S. MITCHELL.

The referee on dairy products read the following report:

REPORT ON METHODS FOR THE ANALYSIS OF DAIRY PRODUCTS.

BY L. L. VAN SLYKE, REFEREE.

The cooperative analytical work on dairy products has been limited this year to a study of methods used for determining the casein and albumin in cow's milk.

Some special work has been done by the referee also in order to call attention to some deficiencies existing in the present statement of our official method for determining milk solids.

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[1] See pure-food bill, introduced into the House of Representatives by the Hon. Mr. Brosius. H. R. 5441.

The referee was authorized by vote of the association to study methods for identifying filled cheese and milk adulterants used in the form of milk preservatives. At the suggestion of the chairman of the committee, appointed to report methods for the detection of food adulterants, I have made the present report cover dairy products in general.

DETERMINATION OF CASEIN AND ALBUMIN IN COW'S MILK.

There is probably no class of compounds in agricultural chemistry about which there is more variation of statement than the nitrogen compounds of cow's milk. Thus, Duclaux declares there is only one, while Halliburton says unqualifiedly, "The proteids which occur in milk are two in number." Wiley names four, but states that the number and kind of proteid bodies are not known with definiteness. Sebelien says that milk contains globulin, and Halliburton says this is a mistake. New nitrogen compounds are frequently reported as being found in milk.

The referee did not have it in mind to harmonize these disagreements or settle these disputed questions, but simply to assume as true what is most palpable, and study methods based on these assumptions.

From general chemical behavior we can assume, with our present light, that cow's milk contains at least three kinds of nitrogen compounds. First in quantity is casein, which is coagulated by acids, rennet, rennet-like ferments, by saturation with neutral salts like magnesium sulphate, sodium chlorid, etc., or through precipitation by various other metallic salts. Casein can not be separated from other milk constituents by heat alone. The nitrogen compounds remaining in milk after the removal of casein appear to be of two kinds, one kind called albumin and rendered insoluble by heating at 75° C. or higher. Then there always remains, so far as my own experience goes, a class of nitrogen compounds which is not affected either by heat or by the reagents used to remove casein.

To separate and estimate the casein and albumin of milk, two methods have been used for study: First, the provisional method adopted last year, that is, precipitation of casein by acetic acid and determination of albumin in filtrate by boiling; and second, precipitation of casein by saturation with magnesium sulphate and determination of albumin in acidified filtrate. The latter method has been carried out as follows: To about 5 grams of milk, 50 cc of solution of magnesium sulphate, saturated at 40° to 45° C., are added and the mixture heated to 40° to 45° C. until the precipitate completely separates, leaving the surrounding liquid clear. The precipitate is filtered, washed two or three times with warm saturated solution of magnesium sulphate, and then treated by the Kjeldahl method for the determination of nitrogen. To the filtrate is added 0.3 cc of a 10 per cent solution of acetic acid and the temperature is raised to boiling until the albumin completely precipitates. The precipitate is filtered, washed with saturated magnesium sulphate solution, and then treated by the Kjeldahl method for the determination of its nitrogen. Some work has been done also by the Geneva Station on a modification of the provisional method for determining albumin which will be described later.

Three different samples of milk were sent on different dates, as follows:

On June 14, to the Indiana, Iowa, and Cornell University experiment stations.

On July 26, to the Department of Agriculture at Washington, and to the Wisconsin Experiment Station.

On September 13, to the Cornell University, Maine, Delaware, Kentucky, Vermont, and Ottawa (Canada) experiment stations, and to the Department of Agriculture.

These samples were examined at the Geneva Experiment Station in every case. The work was performed by the following chemists: Cornell University, C. G. Cavanaugh; Department of Agriculture, G. E. Patrick and T. C. Trescot; Geneva, J. A. Le Clerc and L. L. Van Slyke; Indiana, H. A. Huston; Iowa, I. J. Mead; Kentucky, M. A. Scovell and A. M. Peter; Maine, J. M. Bartlett; Ottawa (Canada), F. T. Shutt; Vermont, C. H. Jones; Wisconsin, Alfred Vivian.

The samples sent out consisted of freshly separated skim milk, and contained for each liter 1 cc of 40 per cent formaldehyde solution to keep the casein from undergoing change. In this connection, it was desired to ascertain whether the presence of formaldehyde in this amount would affect the determination of casein or albumin by either method, and also whether on long standing the casein would undergo change in the presence of formaldehyde.

The following results indicate that the presence of formaldehyde in the comparatively large proportion used has no influence upon the precipitation of the casein or albumin by the methods employed.

Effect of formalin in milk.

Quality of milk.	Percentage of casein by provisional method.	Percentage of casein by magnesium sulphate precipitation.	Percentage of albumin by provisional method.	Percentage of albumin by magnesium sulphate method.	Percentage of albumin by modified provisional method.
In milk containing no formalin..........	(a) 2.96	(a) 3.24	(a) 0.388	(a) 0.469	(a) 0.463
	(b) 2.98	(b) 3.26	(b) .400	(b) .475	(b) .475
	(c) 3.01	(c) Lost.	(c) .425	(c) .500	(c) .481
	(d) 3.04	....	....	....	....
	(e) 3.05	....	....	....	....
	(f) 3.06	....	....	....	....
Average.........................	3.02	3.25	.404	.481	.473
In milk containing formalin............	(a) 3.01	(a) 3.21	(a) .406	(a) .413	(a) .425
	(b) 3.01	(b) 3.22	(b) .406	(b) .444	(b) .444
	(c) 3.04	(c) 3.24	(c) .413	(c) .450	(c) .463
	(d) 3.05	....	....	....	....
	(e) 3.06	....	....	....	....
	(f) Lost.	....	....	....	....
Average.........................	3.03	3.22	.408	.436	.444

That formalin is a most excellent preservative for keeping samples of milk for analysis our results, presented below, show conclusively. The sample of milk, which was sent out on June 14, was analyzed for casein and albumin at six different times between June 14 and July 26. The sample during these several weeks stood in the laboratory, where it was fairly warm.

The amount of casein as found by the provisional method was as follows:

(1) Sample sent out June 14:

	Per cent.
June 14	2.54
17	2.57
19	2.62
25	2.59
July 19	2.59
26	2.66

(2) Sample sent out July 26:

	Per cent.
July 26	2.62
Aug. 2	2.68
12	2.61
25	2.59

The results obtained by the magnesium sulphate method were equally uniform. The albumin determinations were less uniform, but fairly good. We may safely conclude that formaldehyde will keep milk in perfect condition for analysis for a reasonable length of time, and especially if any precautions whatever be taken to keep the milk in a fairly cool place.

Therefore, any difference existing in the results obtained by different workers can not be due to the fact that the milk underwent change before being examined; and, moreover, the work was completed in every case with reasonable promptness after the receipt of the samples.

MODIFICATION OF PROVISIONAL METHOD FOR DETERMINATION OF ALBUMIN.

Some time ago we noticed irregularities in determining albumin by the provisional method which seemed to point to low results. It occurred to us that under some conditions the amount of acetic acid used for precipitating casein might be sufficient to hold some albumin in solution. We therefore made a series of comparisons, neutralizing by caustic alkali the filtrate from casein precipitation and then adding 0.3 cc of 10 per cent solution of acetic acid. The latter method quite uniformly gave higher results, varying somewhat in different milks. The data for the comparisons are here presented.

Results from sample No. 1.

Stations.	Percentage of casein by provisional method.	Percentage of casein by magnesium sulphate method.	Percentage of albumin by provisional method.	Percentage of albumin by magnesium sulphate method.
New York (Geneva)	(a) 2.44	(a) 2.65	(a) 0.225	(a) 0.275
	(b) 2.54	(b) 2.66	(b) .238	(b) .300
	(c) 2.54	(c) 2.70	(c) .244	(c) .325
	(d) 2.54	(d) 2.71	(d) .256	(d) .325
	(e) 2.62	(e) 2.76	(e) .262	(e) .344
Average	2.54	2.70	.245	.314
Indiana	(a) 2.62	(a) 2.93	(a) Lost.	(a) .371
	(b) 2.63	(b) 3.02	(b) .401	(b) .358
	(c) 2.63	....	(c) .379	....
Average	2.63	2.97	.390	.365
Iowa	2.66	2.78	.219	.197

Results from sample No. 2.

Stations.	Percentage of casein by provisional method.	Percentage of casein by magnesium sulphate method.	Percentage of albumin by provisional method.	Percentage of albumin by magnesium sulphate method.
New York (Geneva)	(a) 2.59	(a) 2.72	(a) 0.231	(a) 0.281
	(b) 2.60	(b) 2.77	(b) .262	(b) .312
	(c) 2.62	(c) 2.78	(c) .287	(c) .363
	(d) 2.67	(d) 2.79	(d) .306	(d) .400
	(e) 2.68	(e) 2.84	(e) .331	(e) .406
Average	2.63	2.78	.283	.352
Department of Agriculture	(a) 2.56	(a) 2.69	(a) .325	(a) .244
	(b) 2.56	(b) 2.69	(b) .338	(b) .244
	(c) 2.63	(c) Lost.	(c) .344	(c) .244
Average	2.58	2.69	.335	.244
Wisconsin	(a) 2.50	(a) 2.62	(a) .313	(a) .100
	(b) 2.50	(b) 2.63	(b) .314	(b) .120
	(c) 2.54	(c) 2.64	(c) .318	(c) .120
	(d) 2.56	(d) 2.65	(d) .330	(d) .125
Average	2.53	2.63	.319	.116

Results from sample No. 3.

Stations.	Percentage of casein by provisional method.	Percentage of casein by magnesium sulphate method.	Percentage of albumin by provisional method.	Percentage of albumin by magnesium sulphate method.	Percentage of albumin by modified provisional method.
New York (Geneva)	(a) 2.71	(a) 3.04	(a) 0.269	(a) 0.288	(a) 0.362
	(b) 2.76	(b) 3.10	(b) .300	(b) .325	(b) .369
	(c) 2.79	(c) Lost.	(c) .344	(c) .369	(c) .387
Average	2.75	3.07	.304	.327	.373
New York (Cornell)	(a) 3.10	(a) 3.19	(a) .317	(a) .270	....
	(b) 3.30	(b) 3.23	(b) .360	(b) .317	....
Average	3.20	3.21	.338	.293	....
Kentucky	(a) 2.84	(a) 2.85	(a) .32	(a) .34	....
	(b) 2.86	(b) 2.88	(b) .33	(b) .39	....
	....	(c) 2.90	....	....	....
	....	(d) 2.92	....	....	....
	....	(e) 2.93	....	....	....
Average	2.85	2.90	.325	.365	....
Maine	(a) 2.71	(a) 2.91	(a) .275	(a) .425	....
	(b) 2.71	(b) 2.94	(b) .288	(b) .425	....
	(c) 2.73	(c) 2.94	(c) .306	(c) .450	....
Average	2.72	2.93	.288	.431	....
Vermont	(a) 2.69	(a) 2.69	(a) .252	(a) .42	....
	(b) 2.72	(b) 2.69	(b) .250	(b) .425	....
	(c) 2.73	....	(c) .250	....	....
Average	2.71	2.69	.251	.422	....
Department of Agriculture	(a) 2.63	(a) 2.63	(a) .263	(a) .175	....
	(b) 2.63	(b) 2.69	(b) .263	(b) .175	....
	(c) 2.63	(c) 2.75	(c) .275	(c) .175	....
Average	....	....	[1] .267	[1] .175	....
	....	(d) 2.75	(a) .206	(a) .137	....
	....	(e) 2.75	(b) .156	(b) .106	....
	....	(f) 2.75	(c) .175	(c) .137	....
Average	2.63	2.72	[2] .179	[2] .127	....
Ottawa (Canada)	(a) 2.61	....	(a) .37	....	....
	(b) 2.67	....	(b) .37	....	....
Average	2.64	....	.37	....	....

[1] Washing albumin with cold water.

[2] Washing albumin with hot water.

Summary of analytical results.

Stations.	Percentage of casein by provisional method.	Percentage of casein by magnesium sulphate method.	Percentage of albumin by provisional method.	Percentage of albumin by magnesium sulphate method.	Percentage of albumin by modified provisional method.
Sample 1:					
New York (Geneva)	2.54	2.70	0.245	0.314	....
Indiana	2.63	2.97	.390	.365	....
Iowa	2.66	2.78	.219	.197	....
Average	2.61	2.82	.285	.292	....
Sample 2:					
New York (Geneva)	2.63	2.78	.283	.352	....
Department of Agriculture	2.58	2.69	.335	.244	....
Wisconsin	2.53	2.63	.319	[1].116	....
Average	2.58	2.70	.312	.298	....
Sample 3:					
New York (Geneva)	2.75	3.07	.304	.327	0.373
New York (Cornell)	[1]3.20	3.21	.338	.293	....
Kentucky	2.85	2.90	.325	.365	....
Maine	2.72	2.93	.288	.431	....
Vermont	2.71	2.69	.251	.422	....
Department of Agriculture	2.63	2.72	[2].267	[2].175	....
			[3].179	[3].127	....
Ottawa (Canada)	2.64	....	.370	....	....
Average	2.72	2.92	.306	.368	....

[1] Omitted from average.

[2] Washing albumin with cold water; omitted from average.

[3] Washing albumin with hot water; omitted from average.

The data contained in the preceding tables may be summarized as follows:

(1) In the determination of casein we find a good agreement in the duplicates of individual workers by either method.

(2) In the first sample the results of three workers gave casein varying from 2.54 to 2.66 per cent of casein by the provisional method, and from 2.70 to 2.97 per cent by the magnesium sulphate method.

In the second sample the results of three workers gave casein varying from 2.53 to 2.63 per cent by the provisional method and from 2.63 to 2.78 per cent by the magnesium sulphate method.

In the third sample the results of six workers gave casein varying from 2.63 to 3.20 per cent, or, dropping the highest result, from 2.63 to 2.85 per cent by the provisional method and from 2.69 to 3.21 or 3.07 per cent by the magnesium sulphate method.

(3) Comparing the provisional method with the magnesium sulphate method for determining casein, we find that eleven out of twelve workers obtained more casein by the latter method, the difference varying from 0.01 to 0.34 per cent and averaging 0.15 per cent. In only one case was less casein obtained by the magnesium sulphate method and the difference then was only 0.02 per cent.

(4) When we consider that these results are based on the nitrogen determination, and that any error in determining nitrogen is multiplied over six times when we express the results in terms of casein, we may regard the results obtained as very satisfactory, especially when we consider, in addition, that the work was new to most of the analysts.

Every one complained of the tediousness of the magnesium sulphate method, the time of filtration and washing varying from several hours to three days, as reported by different workers.

While it is evident that acetic acid does not always effect a complete precipitation of casein, yet the difference usually lies below 0.20 per cent, and only in work requiring exceeding accuracy would the tediousness involved in using the magnesium sulphate method justify the added labor. The referee hopes by further work to perfect the provisional method, so that all of the casein may be precipitated.

(5) In the first sample, the results of three workers gave albumin varying from 0.219 to 0.39 per cent by the provisional method and from 0.197 to 0.365 per cent by the magnesium sulphate method.

In the second sample, the results of three workers gave albumin varying from 0.283 to 0.335 per cent by the provisional method and from 0.116 to 0.352 per cent by the other method.

In the third sample, the results of six workers gave albumin varying from 0.251 to 0.338 per cent by the provisional method and from 0.175 to 0.431 by the magnesium sulphate method.

(6) Comparing the provisional method with the magnesium sulphate filtrate method for determining albumin, we find that six workers obtained more albumin by the provisional method and a half dozen other workers obtained more by the other method. However, the average of all results gives albumin by the provisional method as 0.30 and by the other method as 0.34 per cent.

(7) Neither of the methods employed above seems to give concordant results in the hands of different workers. It appears that the methods are faulty.

(8) Mr. Patrick made some determinations, in which he compared the use of cold (room temperature) and hot water in washing the precipitated albumin. With both methods under discussion, he secured higher results with cold water.

Some similar determinations have been made in the Geneva laboratory on other samples of milk since receiving Mr. Patrick's results.

With the provisional method we found very little difference in the use of hot or cold water, the slight difference being in favor of hot water.

Results in washing albumin.

Treatment.	Sample A.	Sample B.
	Per cent.	*Per cent.*
Hot water (80 cc)	0.300	0.331
Cold water (80 cc)	.272	.312

With the magnesium sulphate filtrate method we found the reverse true. From special work which we have done since sending out samples it seems necessary to wash the albumin precipitate with saturated solution of magnesium sulphate if reliable results are to be secured.

Results in washing albumin.

Treatment.	Sample A.	Sample B.
	Per cent.	*Per cent.*
Washing with cold water (80 cc)	0.163	0.169
Washing with hot water (80 cc)	.119	.154
Washing with magnesium sulphate solution		.385

MODIFIED PROVISIONAL METHODS COMPARED.

In making a comparison some time ago between the provisional and modified methods for determining albumin in 45 different milks, the provisional method gave an average of 0.315 per cent of albumin and the modification gave an average of 0.345 per cent. In 6 cases of the 45, the modification gave an average of 0.03 per cent less; in 9 cases there was no difference, and in 30 cases the modification gave more by amounts varying from 0.01 to 0.12 per cent and averaging 0.05 per cent.

In the Geneva laboratory we have in two trials with different samples obtained slightly higher results in washing with cold water.

Results in washing albumin.

Treatment.	Sample A.	Sample B.
	Per cent.	*Per cent.*
Washing with cold water (80 cc)	0.346	0.387
Washing with hot water (80 cc)	.321	.371

DETERMINATION OF WATER IN MILK.

The phraseology employed in describing the determination of water in milk is decidedly faulty. It came about from a condensation of two methods into one without preserving the essential conditions of the two methods. It directs to heat until apparently dry and then heat for one hour at the temperature of boiling water. The phrase "apparently dry" is too indefinite. The temperature of boiling water is not necessarily high enough to complete the drying in one hour, unless we are where the boiling point is close to 100° C. When we use a steam-drying oven, as so many do, the temperature rarely reaches 100° C.

In a large number of determinations we found that when we used a steam oven it required from one and one-half to two hours to evaporate to constant weight with sand and from two to two and one-half hours or longer without sand, other conditions being uniform. The use of a water bath sometimes gave more rapid drying than the steam oven, and sometimes not.

The method should be more elastic as to time of drying and should be to constant weight rather than for a fixed time.

METHODS FOR DETECTION OF ADULTERATIONS IN DAIRY PRODUCTS.

It has not been the referee's design to make any attempt at an exhaustive consideration of this subject. The number and kinds of adulterants actually used in milk and its products are comparatively few. It would be a waste of time to treat of forms of adulteration which are possible, but which are rare in actual occurrence.

An attempt has been made to give standards in a broad way. These may be open to objection as presented, but they will invite discussion and will result, it is hoped, in a consensus of opinion more important than any other that has been put on record in this country in reference to a somewhat vexatious field.

So far as it is deemed desirable, the referee has tried the tests recommended and not already a part of the association's methods, and given only those which were found to work in his hands.

DETECTION OF ADULTERATIONS OF MILK.

(1) *Forms of adulteration.*—There are three kinds of adulteration in milk which are common: First, addition of water; second, removal of fat or addition of skim milk; and, third, addition of preservatives, most prominent among these being borax, boracic acid, and formaldehyde.

(2) *Methods of detection.*—In general, it may be said that the specific gravity test by itself furnishes very little evidence in regard to the purity of milk. As regards the detection of watering or skimming, the question becomes one mainly of the inter-

pretation of results secured by a determination of fat or solids or both, in the light of a State legal standard. The chemical methods are detailed under the analysis of milk.

(a) DETECTION OF FORMALDEHYDE.

(1) When milk contains not less than 1 part of formaldehyde in 10,000 parts, a violet or bluish color is formed by pouring the milk into a test tube containing concentrated sulphuric acid in which there is present a trace of ferric chlorid. The color forms at the junction of the two liquids.

(2) When small quantities of formaldehyde are present, distill the milk until a distillate of several cubic centimeters is obtained. To this distillate add one drop of a very dilute aqueous solution of phenol and pour the mixture upon concentrated sulphuric acid in a test tube. A bright crimson color appears at the zone of contact. This is readily seen when the milk contains as little as 1 part of formaldehyde in 200,000 parts. If the proportion be greater than 1 to 100,000, there is above the red ring a white milky zone, and if more concentrated there will be a white or pinkish curdy precipitate.

(b) DETECTION OF BORAX AND BORACIC ACID.

(1) On a porcelain surface place one drop of milk, two drops of strong hydrochloric acid, and two drops of fresh, saturated, turmeric tincture (or turmeric powder). Dry on water bath; remove as soon as dry; cool, and add one drop of ammonia with a glass rod. A slaty-blue color forms, changing to green. This detects 1 part of borax in 1,000 parts of milk. When the amount is less, the test gives a green but not a blue tint.

This method may be carried out also as follows: Incinerate a few drops of milk; treat with a little water; make just acid with hydrochloric acid; add a few drops of turmeric solution, and evaporate to dryness in a porcelain dish. Moisten with dilute ammonia. A dark-blue solution forms, rapidly disappearing.

(2) Evaporate one or two drops of milk with an equal quantity of fresh, saturated, turmeric tincture. Then add one drop of strong hydrochloric acid, drawing acid over residue with a glass rod. Apply heat again for a few seconds, when, if either borax or boracic acid be present, a color is formed, ranging from pink to dark red. Cool, and confirm presence of borates by adding a drop of ammonia.

(3) *Chemical standards of purity for milk.*—The standards for pure milk vary widely in the different States. In some, fat alone is fixed; in others, total solids alone; in still others, both fat and solids are fixed; while in a few cases total solids and solids-not-fat are used. No State, except one or two, has a standard lower than 3 per cent for fat and 12 per cent total solids. In some of the countries and municipalities of Europe, the lowest limit of fat is fixed as 2.5 per cent and of total solids as 11.5 per cent. It is safe to say that while the milk of some herds of cows may occasionally fall below 3 per cent in fat, and more often below 12 per cent in solids, still milk containing less than 3 per cent of fat and 11.5 of solids at the same time is open to suspicion as having been watered. Milk in which the total nitrogen compounds (total nitrogen multiplied by 6.25) are equal to the fat may be safely regarded as having been skimmed or diluted with skimmed milk. Milk containing any form of preservative or coloring matter is in most States regarded as adulterated.

DETECTION OF ADULTERATIONS OF BUTTER.

(1) *Forms of adulteration.*—The most common adulteration of butter is substitution, in part or whole, of fat other than butter-fat. Occasionally preservatives are found, such as occur in milk. Excessive water or casein should be regarded as adulteration.

(2) *Methods of detection.*—The methods commonly employed for detecting fats foreign to pure butter are given in Bulletin No. 46, Department of Agriculture, Division of Chemistry, on pages 26 to 35.

(3) *Standard of purity for butter.*—The per cent of fat in butter should reach 80. Water should not exceed 18 per cent, and preferably should keep down to 15. Nitrogen compounds should not go much above 1 per cent.

For the purpose of determining the purity of butter-fat, the following processes are usually regarded as most helpful, their value ranking in the order given:

(1) Determination of Reichert-Meissl number—that is, the number of cubic centimeters of one-tenth normal solution required to neutralize completely the volatile acids obtained from 5 grams of fat. When this number falls below 25, the sample is open to suspicion; and when it falls to 23 or below, the sample is usually condemned.

(2) Determination of specific gravity at 40° C. When this falls below 0.91, it indicates cause for suspicion, and should be considered with other factors.

(3) Determination of the saponification equivalent or Koettstorfer's number—that is, the number of milligrams of KOH neutralized in saponifying one gram of fat. This should not be under 220.

(4) Determination of the insoluble fat acids, expressed as Hehner's number, which is the number of parts of insoluble fat acids in 100 parts of fat. In pure butter-fat this number rarely goes above 89, but has been found as high as 90.

DETECTION OF ADULTERATIONS OF CHEESE.

(1) FORMS OF ADULTERATION.

There are only two kinds of adulteration in cheese which are common: First, the use of fat other than milk-fat, producing the so-called filled cheese; and second, the removal of fat in varying degrees, producing so-called skim cheese.

(*a*) Filled cheese is made from a mixture consisting of separator skim milk mixed in an intimate way with liquid fats or oils derived from the fat of swine and cattle. Hence, the chemical means most commonly used for detecting filled cheese are the same as are employed in detecting adulterated butter.

Since the amount of fat which can be mechanically held by skim milk is less than 3 per cent, there will be found in filled cheese a larger amount of casein in proportion to fat than is found in whole milk cheese.

(*b*) Skim milk cheese made from milk which has been skimmed enough to pay can readily be detected by the relation of fat to nitrogen compounds or to solids-not-fat, or, less certainly, by the amount of fat in cheese.

(2) METHODS OF DETECTION.

(1) Preparation of sample. Henzold's method, as described by Wiley, in Principles and Practice of Agricultural Analysis, is as follows: "The cheese, in quantities of about 300 grams, is cut into fragments about the size of a pea and treated with 700 cc of potash lye, which has previously been brought to a temperature of about 20°. The strength of the lye should be such that about 50 grams of the caustic potash are contained in each liter of the solution. The treatment is conveniently conducted in a wide-neck flask and the solution of the casein is promoted by vigorous shaking. After from five to ten minutes it will be found that the casein is dissolved and the fat is found swimming upon the surface of the solution in lumps. The lumps of fat are collected in as large a mass as possible by a gentle shaking to and fro. Cold water is poured into the flask until the fat is driven up into the neck, whence it is removed by means of a spoon. The fat obtained in this way is washed a few times with as little cold water as possible in order to remove the residue of potash lye which it may contain. Experience shows that the fat by this treatment is not perceptibly attacked by the potash lye. In a short time, by this procedure, the fat is practically all separated and is then easily prepared for chemical analysis by filtering and drying," as described in Bulletin No. 46, Division of Chemistry, United States Department of Agriculture, page 27, 3-(a).

The fat may be less conveniently obtained from the cheese by reducing the partially dried sample to a finely divided state and applying any of the usual solvents. The solvent is removed from the extract by evaporation and the residual fat is filtered and prepared for examination as usual.

The fat may be separated also in the following manner: The cheese is ground fine by cutting into strips and passing through a meat-cutting machine. It is then placed in a flask and warm water poured upon it in the proportion of 1 cc for each gram of cheese. Agitate thoroughly. Add slowly in small quantities at a time sulphuric acid of sp. gr. 1.82 to 1.825, agitating thoroughly after each addition of acid. Use in all an amount of acid equal to the amount of water used. After standing a few minutes, the fat separates and can be removed by use of a separatory funnel, after which it can be washed free from acid and then filtered and dried.

(2) Determination of Reichert-Meissl number, Hehner's number, etc. See Bulletin No. 46, pages 26 to 35, United States Department of Agriculture, Division of Chemistry.

(*b*) *Skim-milk cheese.*—Determine the per cent of fat and of nitrogen compounds or of total solids, as directed in Bulletin No. 46, page 37, and Circular No. 2, page 3, United States Department of Agriculture, Division of Chemistry.

3. CHEMICAL STANDARDS OF PURITY FOR CHEESE.

(*a*) Filled cheese.—In respect to purity of fat in cheese, Dr. Crampton writes the referee as follows: "I have no hard and fast standard, being guided by the circumstances in each case and by the results obtained from other tests, if the Reichert-Meissl figure be low. Most of my samples, both of cheese and butter, present no difficulties. The English standard of 24 is about as good as any, in my opinion; though I would not condemn a cheese-fat or butter-fat which went below this, if it gave normal figures by other tests."

In filled cheese the proportion of fat to nitrogen compounds and to total solids falls below that of whole-milk cheese. In pure cheese, fat rarely, if ever, forms less than 50 per cent of the total solids, and in relation to the nitrogen compounds, fat rarely falls as low as 1.25 pounds for each pound of nitrogen compounds.

(*b*) Skim-milk cheese.—When the per cent of fat in cured cheese falls below 32 or 33, there is ground for suspicion that it is skim-milk cheese. But a more reliable guide is the relation of fat to total solids or to total nitrogen compounds as given above.

RECOMMENDATIONS.

The referee makes the following recommendations:

1. That the provisional method for determining casein in cow's milk be made official, inserting in line 3, page 2 (circular No. 2), after "add," the following words: "1 part of formaldehyde to 2,500 parts of milk or," and in the first line of the second paragraph substitute the word "preservatives" for "mercuric chlorid."

2. That the modified provisional method for determining albumin in cow's milk be substituted as a provisional method for the present provisional method, and that further cooperative work be done on the determination of albumin.

3. That the magnesium sulphate method for determining casein in cow's milk be made an official optional method.

4. That under milk analysis (*a*) (Bull. No. 46) the phraseology of the first and second sentences be changed to read as follows: "Heat to constant weight from 1 to 2 grams of milk in a tared flat dish, having a diameter of not less than 5 centimeters, containing from 15 to 20 grams of pure dry sand, or without sand, at the temperature of boiling water."

5. That, under the different divisions of dairy products, in the association's methods of analysis, there be added the following head and subheads: "Adulterations: (1) Forms, (2) Methods of detection, (3) Standards of purity;" and that under each be incorporated, in briefest form practicable, such statements as may hereafter be decided upon by the association.

CHANGES RECOMMENDED IN METHODS OF MILK ANALYSIS.

(c) Determination of nitrogen compounds.

(1) Total nitrogen compounds.

Place in Kjeldahl digestion flask a known weight (about 5 grams) of milk, and proceed, without evaporation, exactly as described for this method under nitrogen, page 36, Bull. No. 46. Multiply the percentage of nitrogen by 6.25 for nitrogen compounds.

(2) Determination of casein in cow's milk by precipitation with acetic acid.

When it is not practicable to make the determination of casein in cow's milk within twenty-four hours from the time of milking, add 1 part of formaldehyde to 2,500 parts of milk, or 1 part of mercuric chlorid to 2,000 parts of milk, and keep in a cool place.

Weigh about 10 grams of milk, dilute in a beaker with about 90 cc of water at 40° to 42°, and add at once 1.5 cc of a solution containing 10 per cent of acetic acid by weight. Stir with a glass rod and let stand from three to five minutes longer. Then decant on filter, wash two or three times with cold water by decantation, and then transfer precipitate completely to filter. Wash once or twice on filter. The filtrate should be clear, or very nearly so. If the filtrate be not clear when it first runs through, it can generally be made so by two or three repeated filtrations, after which the washing of the precipitate can be completed. The washed precipitate and filter paper are then digested as in the regular Kjeldahl method for the determination of nitrogen, and the process is completed as usual. To calculate the nitrogen into an equivalent amount of casein, multiply the per cent of nitrogen by 6.25.

In working with milk which has been kept with preservatives, the acetic acid should be added in small portions, a few drops at a time, with stirring, and the addition continued until the liquid above the precipitate becomes clear, or very nearly so.

(3) Determination of casein in cow's milk by precipitation with magnesium sulphate.

Prepare a saturated solution of nitrogen-free magnesium sulphate at a temperature of 40° to 45° C. Add 50 cc of this solution to about 5 grams of milk and heat the mixture to from 40° to 45° C. until the precipitate completely separates, leaving the surrounding liquid clear. The precipitate is filtered and washed two or three times with the warm saturated solution of magnesium sulphate and then treated by the Kjeldahl method for the determination of nitrogen.

This method usually gives 0.1 to 0.2 per cent more of casein than the preceding, but the filtration is very tedious and, except when exceeding accuracy is required, the precipitation by acetic acid is sufficiently accurate for most purposes.

(4) Provisional method for the determination of albumin in cow's milk.

The filtrate obtained above in separating casein by acetic acid precipitation is just neutralized by nitrogen-free caustic alkali. Then add 0.3 cc of a 10 per cent solution of acetic acid and place in a water bath, heated to the boiling temperature of water, until the albumin separates, leaving a clear solution. The filtered and washed precipitate is then treated by the Kjeldahl method for determining nitrogen. The amount of nitrogen multiplied by 6.25 gives the amount of albumin.

(a) Determination of water.

(1) Evaporation in open dish.

Heat to constant weight from 1 to 2 grams of milk in a tared flat dish, having a diameter not less than 5 centimeters, containing from 15 to 20 grams of pure dry sand, or without sand, at the temperature of boiling water. Cool in a desiccator, and weigh rapidly to avoid absorption of hygroscopic moisture.

(2) Babcock asbestus method. (Unchanged.)

FOOD ADULTERATION.

By W. D. BIGELOW, *Referee*, and W. S. SWEETSER, *Associate Referee.*

Mr. Bigelow, referee on fermented and distilled liquors, read the following report:

At the last meeting of the association your referee was instructed to discontinue work for the present in the line of fermented and distilled beverages, and to report methods for the determination of food adulterants. It has not been found possible to include the whole subject of food adulteration, but methods have been compiled, with the collaboration of Mr. W. S. Sweetser, the associate referee, for the following classes of foods: Flour, bread, mustard, pepper, cayenne, ginger, cinnamon, cloves, allspice, nutmeg, mace, cream of tartar, baking powder, vinegar, canned foods, wine, beer, and cider. A separate chapter is also devoted to the detection of preservatives.

FLOUR AND MEAL.

Flour is a finely divided and bolted product of a single cereal. Meal is more coarsely ground, is not bolted, and in the case of barley is prepared from the unhulled grain.

The forms of adulteration to be expected are: Admixture with mineral matter to increase the weight of the flour, or with alum to improve its physical appearance; and the addition of flour or meal from the cheaper cereals. The flour may also contain seeds of weeds, such as cockle (*Lychnis githago*) and purple cow wheat (*Melampyrum arvense*); its water content may be too high; it may be more or less decomposed, or it may be made from a grain affected with fungi.

In examining flour for adulterations, the percentages of ash, fiber, ether extract, and proteids are all of value. The table below gives the extreme percentages of these compounds. It must be understood that this table is only provisional, and it will frequently happen that products which are not adulterated will not fall within these limits. At the same time it is believed that all samples of first-class flour and meal should do so.

Composition of flours and meals.

[Calculated to water-free substances.]

Flours and meals.	Moisture.		Ash.		Proteids n. × 6.25.		Fiber.		Ether extract.		Nitrogen-free extract.	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
	Pr. ct.	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*
Wheat flour	15.0	9.0	0.8	0.3	15.0	8.0	1.0	0.1	2.0	0.5	90.0	82.0
Rye flour	14.0	12.0	1.5	.5	1.0	6.0	0.6	.4	1.0	.9	92.0	88.0
Buckwheat flour	18.0	12.5	1.5	.8	9.5	5.0	.6	.3	2.0	.8	93.0	84.0
Barley flour	15.0	10.0	2.0	1.0	12.0	8.5	.6	.3	2.0	.5	92.0	87.0
Pea flour	15.0	8.0	3.2	2.8	25.0	21.0	20.0	12.5	2.0	1.0	60.0	55.0
Bean flour	17.0	10.0	4.0	3.0	26.0	22.0	4.0	3.5	2.5	1.5	70.0	65.0
Vetch flour	16.0	10.0	3.5	1.6	35.0	30.0	......	......	2.5	1.5	......	......
Rice flour	15.0	10.0	.6	.3	10.0	7.0	.4	.1	0.6	.3	90.0	85.0
Potato flour	14.0	9.0	6.5	3.0	13.0	6.0	4.5	1.5	.8	.3	90.0	75.0
Graham flour	15.0	11.0	2.2	1.8	15.0	10.0	2.4	2.0	2.2	1.9	72.0	70.0
Barley meal	15.0	10.0	4.5	1.7	17.0	9.0	8.0	6.5	3.7	1.7	78.0	72.0
Oatmeal	10.0	6.0	2.4	2.0	18.0	14.0	1.4	.7	9.5	6.5	76.0	72.0
Corn (maize) meal	18.0	8.0	4.5	1.0	1.5	8.0	3.5	.7	6.0	2.5	80.0	63.0
Pearled barley meal	15.0	10.0	2.0	1.0	12.0	8.5	.6	.3	2.0	.5	87.0	92.0

Wheat flour is subjected to a far greater amount of adulteration than all other flours and meals. It will therefore be of the greatest importance to give this product especial attention. In its physical characteristics wheat flour is a white, fine powder with only the slightest yellow tinge. To judge of the color the sample should be examined in thin layers with a light not too strong. The flour should be free from acidity and its odor sweet and agreeable. When pressed with a smooth surface no bran should be revealed to the naked eye or the lens. The hand plunged into it should not experience a cooling effect. When pressed in the hand it should retain its shape for some time. A microscopic examination should reveal no foreign matter such as starches of other cereals, fungi, or weed seed. The aqueous extract should not exceed 5 per cent.

It is probable that the adulteration of flour with mineral matter, for the sake of increasing its weight, is now scarcely practiced in this country at all. It can readily be detected, however, by an abnormally high ash, and the qualitative examination of the ash will reveal the nature of the mineral used for adulteration.

DETECTION OF ALUM AND SAND.

Mix 50 grams of flour with water to form a thin paste, and then a few drops of a freshly prepared solution of logwood in alcohol. The mixture is then made alkaline with ammonium carbonate. The presence of alum will be indicated by the formation, sometimes after several hours, of a lavender-blue colored lake. Blyth prefers to immerse a strip of gelatin for twelve hours in a cold aqueous extract of the flour and subsequently in an alcoholic tincture of logwood, made alkaline with ammonium carbonate.[1] The following method is often preferable. Place 200 grams of the sample in a separatory funnel and shake with a sufficient amount of chloroform. Allow to stand overnight and carefully remove mineral matters, alum, etc., through the stopcock. The deposit may be further purified by shaking a second time with a small portion of chloroform. It is then transferred to a watch glass with as little chloroform as possible and the chloroform evaporated, the alum dissolved in water and again obtained by crystallization, the crystalline form being noted. The aqueous solution may also be tested with barium chlorid and Nessler's solution. The portion of the sediment insoluble in water may then be examined microscopically and its nature determined.

DETECTION OF FOREIGN CEREALS.

Flour which is adulterated with products manufactured from cheaper cereals presents a much more difficult field. The most satisfactory method of examining it is by means of a microscope.

A very important method for the detection of such adulterants is that for the estimation of gluten. In this determination, 10 grams of the flour are mixed with sufficient water to make a stiff dough and allowed to stand for one hour. It is then kneaded in the hand or in a piece of linen cloth in a vessel of water or, better, under a faucet, until the water which is pressed from the gluten is clear. The gluten thus prepared while fresh should have a very light yellow color—should be tough and of such consistency that it can be pulled out to a thread.

As a rule, the whiter the gluten while still in the moist state the better the quality of the flour. As the color approaches gray and red the flour becomes of a more inferior quality and less digestible, if indeed it be not adulterated with flours manufactured from other cereals. The gluten from good flour on being quickly heated to the temperature of about 150° C., swells and assumes the appearance of bread. Good flour should contain from 25 to 40 per cent of moist gluten and from 10 to 18 per cent of dry gluten. (Dried at 100° C.)

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[1] A gram of finely divided logwood chips is digested for eight or ten hours in 25 cc of alcohol, and to 10 cc of the alcoholic solution 150 cc of water and 10 cc of saturated ammonium carbonate solution are added.

Gluten obtained from a mixture of wheat and rye flour is dark and viscous, without homogeneity; from a mixture of wheat and barley flours, dark, nonviscous, of a dirty, reddish-brown color; from a mixture of wheat and oats, dark yellow; from a mixture of wheat and maize, yellowish and nonelastic.

The gluten obtained from wheat flour which has been mixed with leguminous flour varies in color from a grayish red, in the case of vetch or beans, to green in the case of peas, and has the characteristic odor and taste of leguminous products.

DETECTION OF LEGUMINOUS FLOURS.

The ash of leguminous flour is very deliquescent, is high in chlorids, and turns turmeric paper brown; cereal ash is the reverse. The aqueous extract of the leguminous flour is extremely acid, while that of cereal flour is faintly alkaline. If the filtrate from the gluten determination of flour containing leguminous flour be made alkaline with ammonia, allowed to stand overnight, and the clear liquid decanted, the addition of dilute mineral acid will precipitate legumin.

DETECTION OF POTATO FLOUR.

Rub a portion of flour vigorously in a mortar until a stiff paste is obtained, thin with more water, filter and test the clear filtrate with a drop of a dilute solution of iodin. In the presence of potato flour a deep blue color is produced, while if only wheat flour be present the resulting color is yellow or light orange. If a mixture of cereal flour and potato flour be dried, spread in a thin layer on a glazed black surface, and examined with a lens, the potato flour is indicated by bright and glassy particles in the otherwise dull white substance.

ALCOHOLIC EXTRACT.

Vogel extracts the flour with 70 per cent of alcohol, to which 5 per cent of hydrochloric acid have been added. The extract is colorless if the flour consist only of wheat or rye, pale yellow if adulterated with barley or oats, orange yellow with pea flour, purple red if made from mildewed wheat, and blood red if made from ergotized wheat.

DETECTION OF ERGOT.

The examination of flour for ergot may be preceded by a general preliminary test to determine whether the flour has been damaged by any form of fungus. Vogel directs to stain the sample of the flour with analin violet and examine with the microscope. If the starch granules have been injured by any fungus they will be found to be thoroughly stained. For the presence of ergot or similar fungi, as indicated by this test, both of the following methods should be used. If the presence of damaged starch granules be indicated by this test one of the following methods may be employed:

First method.—Twenty grams of the sample are digested with boiling alcohol as long as any color is extracted. The solution is then treated with 1 cc of sulphuric acid (1:3). The presence of ergot will color the solution red, and if the solution be diluted with quite a volume of water the red coloring matter may be extracted from separate portions by means of chloroform, ether, benzine, or amyl alcohol.

Second method.—Ten grams of the flour under examination are digested for about thirty minutes with a mixture of 20 cc of ether and 10 drops of dilute sulphuric acid (1:5); filter, and wash with ether until the filtrate amounts to 15 cc. The filtrate is then shaken with 5 drops of a saturated solution of sodium bicarbonate. The chlorophyll remains dissolved in the ether and the sodium bicarbonate solution remains clear if the flour be from sound grain, but takes on a deep violet color if ergot be present.

DETECTION OF RICE IN BUCKWHEAT FLOUR.

When pure buckwheat is mixed with water into a thin paste the addition of calcium hydroxid gives a dark green color, which becomes red when acidified with hydrochloric acid. Rice flour with the same treatment gives a yellow color with potassium hydroxid and white with hydrochloric acid. A mixture of buckwheat and rice flours made into paste is changed to a light green color by potassium hydroxid and becomes flesh colored when acidified with hydrochloric acid

BREAD.

The examination of bread for adulterants is very similar to the examination of flour. The more common adulterants are cheaper flours or meals and damaged flour. The addition of alum to bread is also frequently practiced, and instances of the addition of quite an amount of copper sulphate and zinc sulphate are not wanting. The presence of one-tenth of a gram of alum in a one-pound loaf will be detected by immersing a thin slice of bread in the alkaline logwood solution described on page 118 and allowing it to dry in the air. An evident blue color appears after from two to four hours. The presence of more than 0.03 per cent of alum may be detected by immersing a strip of gelatin for ten or twelve hours in the aqueous extract of the bread and then in the logwood solution described on page 118. The aqueous extract is made by digesting 150 grams of the dry ground bread for one or two days in two or three liters of water, then straining the mixture through a bag filter, using vacuum if necessary, and concentrating by evaporation to a small volume.

QUANTITATIVE ESTIMATION OF ALUM.

The ash of 200 grams of bread is treated with hot hydrochloric acid, hot water added and the mixture filtered. The filtrate is treated with a strong excess of sodium hydroxid, boiled again, filtered, and washed. The filtrate thus obtained is treated with a few drops of sodium phosphate, acidified with hydrochloric acid, and the aluminum phosphate precipitated with a slight excess of ammonium hydroxid. The silica is also estimated in a separate portion of the ash. Aluminum compounds commonly occur in the ash of flour, especially in inferior flour, but probably in the form of silicate, and in these compounds the amount of silica present is approximately equal to the amount of alum corresponding to the aluminum present; therefore the weight of added alum may be obtained by subtracting the weight of silica from that of alum. One part of aluminum phosphate is equal to 3.733 parts of ammonium alum and to 4.481 parts of potassium alum.

Copper sulphate may be detected in bread by immersing a thin slice in a very dilute solution of potassium ferrocyanid, made acid with acetic acid. In the detection of foreign flours the methods given under flour and meal may be employed, but it must be remembered that the starch granules are to a large extent destroyed in the process of baking, so that their detection by means of the microscope is a very difficult matter, and with the exception of potato starch is often almost impossible.

The composition of any variety of bread should be approximately the same as that of the flour from which it is manufactured (see page 117), with the exception of the ash and ether extract. The former will be from 0.7 per cent to 1.5 per cent higher, owing to the addition of sodium chlorid, while the latter is often considerably increased by the use of lard. The amount of lard added, however, should not exceed 5 per cent of the weight of the bread. The amount of moisture in wheat bread should not exceed 45 per cent, and will more commonly be between 30 and 40 per cent. If the bread be manufactured from flour which is adulterated with potato flour or rice flour, or if mashed potatoes be added to the dough, the amount of moisture will greatly exceed these limits, and the bread will often be of a clammy consistency.

The presence of fungi and of flours which have been damaged by their action may be recognized by the methods which are given for their detection in flour.

SPICES AND CONDIMENTS.

MUSTARD.

The adulterants which are sometimes found in mustard are wheat flour, potato flour, linseed meal, gypsum, and clay, for the purpose of increasing the weight;

certain seeds, such as radish, rape, *Sinapis arvensis*, cayenne, ginger, and possibly gamboge, for the purpose of increasing weight and also of imparting something of a flavor; and turmeric and martius yellow, and possibly yellow ocher and certain chromates, for the purpose of imparting color. If the adulterant belong to the first class mentioned it will be impossible to identify it except by the use of the microscope. The presence of any flour containing much starch, however, can be detected by boiling 2 grams of the sample in a few cubic centimeters of distilled water for ten minutes, cooling and adding a few drops of iodin solution. The formation of a blue color indicates the addition of some starch or flour. Pure mustard gives no reaction with iodin.

The presence of adulterants can also frequently be proved and in many instances the extent of adulteration be shown by chemical analysis, although, except in the case of adulteration by means of mineral substances, the nature of the adulterant can not be shown. The following limits of analysis will probably include all first-class ground mustards and almost all pure ground mustards:

	Per cent.
Moisture	3 to 8
Ash	4 to 7
Ether extract	31 to 37
Fiber	4 to 6.5
Aqueous extract	30 to 38
Sulphur	1 to 1.6

It frequently happens that the ether extract will be found considerably below the limits given, since the removal of a portion of the oil is often practiced, some houses claiming that the mustard keeps better if a portion of the oil be removed. Instances are recorded also of mustards having a fiber content of from 15 to 17 per cent. A sample exceeding the limits given, however, is to be regarded with suspicion. The color of pure mustard is a very light dull yellow. Wherever a bright yellow is found, coloring matter may be expected. If yellow ocher or barium chromate have been employed, their presence may be readily detected in the ash. The most common coloring matter used in mustard, however, is turmeric. The addition of a strong solution of ammonium hydroxid will usually give an orange-red color in the presence of turmeric. If 2 or 3 grams of the sample be thoroughly mixed with castor oil and filtered, the filtrate, when turmeric is present, will show a marked fluorescence.

A more delicate and perhaps more certain test is to extract a small portion of a sample with two or three times its weight of methyl alcohol, filter, and divide the filtrate into two portions; one portion is then evaporated to dryness. If turmeric be present, the residue will be turned red by hydrochloric acid, which color will be changed to greenish blue on the addition of an excess of alkali. The other portion of the filtrate is evaporated to dryness, moistened with a solution of boric acid, and dried on the steam bath. The presence of turmeric is indicated by a cherry-red color. The addition of alkali then produces a play of colors in which green and purple predominate. Martius yellow, or naphthalene yellow (denitro-naphthol), may be extracted by 95 per cent alcohol from the slightly acidified sample of mustard. This coloring matter dyes wool or silk (but not cotton) a bright yellow. If gamboge be present, the alcoholic extract is turned bright red by sodium hydroxid and yellow by hydrochloric acid.

PEPPER.

Two forms of pepper are commonly sold—black and white pepper—both being the fruit of the *Piper nigrum*, the former being picked while green and allowed to ripen, the latter being allowed to ripen on the plant and then picked and the outer pericarp removed. The common adulterants are ground corn, wheat products, rice, pea flour, buckwheat hulls, cocoanut shells, roasted and unroasted olive stones, mustard husks, linseed meal, sawdust, and cayenne.

Unground pepper is probably not adulterated at present by the admixture of foreign substances. Often, however, the peppercorns are much too small, and a large amount of dust and trash is present. One hundred peppercorns taken at random should not weigh less than 4 grams, and the amount of dust, stems, and trash present in black pepper should not exceed 1½ per cent.

Unground white pepper should be practically free from dust. It is said that artificial peppercorns have been made, though it is probable that there are none on the market in this country. In the examination of ground pepper, the microscope is usually necessary to identify the adulterant used. A sample should be examined in water by direct and by polarized light before and after treating with iodin. Starches should be examined and measured. Stone cells, whether their origin be olive stone or cocoanut shells, may be detected by polarized light, but great care must be taken not to confuse them with the stone cells of the outer portion of the peppercorn. In order to clear the denser tissues, a potassium hydroxid solution may be run under the cover glass after the examination in water, or a fresh portion may be digested twenty-four hours, in a solution of 8 parts of chloral hydrate in 5 parts of water, and examined microscopically in the same medium. In the preparation for the microscopical examination, a portion of the sample may be mixed with an aqueous solution of glycerol (sp. gr. 1.173), in which foreign stone cells will sink to the bottom, while the greater part of the pepper will float or remain suspended in the liquid. The sample may be bleached by allowing it to stand several hours with nitric acid (sp. gr. 1.1), adding powdered potassium chlorate from time to time. The dark-colored portion of the pepper and many vegetable adulterants will be bleached by this method, while charcoal and charred shells will retain their color. The residue from crude fiber determinations should also be examined microscopically, as usually all dark-colored matter occurring in pepper will be bleached in the course of the determinations, with the exception of charred matter. Stone cells will also show their structure best in this residue. The chemical composition of the pepper is also of considerable value in judging of the purity of the sample. The following limits of composition will probably include all good peppers:

Composition of black pepper.

	Per cent.
Moisture	8 to 12
Ash[1]	2.75 to 6.5
Starches, direct inversion by hydrochloric acid	32 to 38
Fiber[1]	9 to 16
Albuminoids	7 to 12
Nonvolatile ether extract not less than	6.5

Composition of white pepper.

	Per cent.
Moisture	12 to 15
Ash	0.8 to 2.9
Starch, direct inversion by hydrochloric acid	40 to 53
Fiber	4 to 8
Albuminoids	8 to 12
Ether extract	7 to 8

If a substance high or low in ash have been added, this will readily be detected in the analysis. The same is true of fiber and fats, while if the adulterant contain approximately the same amount of fat as is found in the pure pepper, a nitrogen determination in the extract obtained by extracting about 10 grams of the pepper with ether, will indicate the adulteration as the ether extract obtained from pepper will contain 2 to 3.5 per cent of nitrogen, owing to the presence of piperin.

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[1] All samples having over 5 per cent of ash or over 11 per cent of fiber should be regarded with suspicion.

CAYENNE.

The fruits of *Capsicum annuum and Capsicum fastigiatum* are ground and placed on the market under the name of cayenne, frequently called cayenne pepper, although the capsicum is not a pepper. As cayenne is sold almost entirely in the ground condition, and in this condition is just as subject to adulteration as other condiments, a very large percentage of the article in the market is adulterated.

The common adulterants which are from time to time reported are hulls of mustard and other spices, corn, rice, and wheat flour, ground stems, red sandal wood, buckwheat middlings, and occasionally mineral matter, such as red ocher, or brick dust, with turmeric as coloring matter. Sometimes, when a deeper color is desired, one of several anilin colors is employed.

The results of chemical analysis are of some importance in judging of the purity of cayenne. The following limits of analysis may be adopted:

	Per cent.
Moisture	2 to 10
Ash	5 to 10
Fiber	16 to 18
Nitrogen	1.7 to 2.2
Ether extract[1]	16 to 30
Alcohol extract	25 to 45

In order to identify the adulterant, and very often to prove that adulteration has been practiced, it is necessary to resort to microscopical examination.

GINGER.

The examination of ground ginger for adulterants presents as great difficulties as that of any other spice.

The common adulterants are exhausted ginger, mustard hulls, clove stems, cayenne, rice, wheat and potato flours, corn meal, and turmeric. The microscope may be used with some satisfaction, except in the case of turmeric and exhausted ginger. The oil cells of turmeric are so similar to those of ginger that the identification of the former as an adulterant of the latter is a very difficult matter. The presence of tutmeric, however, can be detected by means of the methods given under mustard. The presence of exhausted ginger can only be shown by chemical analysis, when the percentage of volatile oil will be found too low, and the other ingredients rather high. The following extremes of composition are suggested:

	Per cent.
Moisture	9 to 12
Ash	3.8 to 7
Soluble ash	1.8 to 2.8
Fiber	2 to 8
Volatile oil[2]	1 to 2.5
Ether extract	4 to 7
Nitrogen	.9 to 1.75
Starch (direct inversion with HCl)	45 to 55

The alcohol extract should be approximately 17 per cent.

CINNAMON AND CASSIA.

Cinnamon is the bark of the small branches of the *Cinnamonum zeylanicum*. It is a native of Ceylon, and the greater part of it is cultivated in gardens in Ceylon. Cassia is the bark of the branches of two other species of the genus cinnamonum, and is produced largely in Bengal, China, and the Indian Archipelago.

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[1] A sample whose ether extract is less than 18 per cent is to be regarded with suspicion.

[2] A sample whose content of volatile oil is less than 1½ per cent is to be regarded with suspicion.

Cinnamon is placed on the market after the removal of the outer and inner coats. Its thickness, therefore, is from one-half to three-fourths of a millimeter. The sticks are always rolled together and consist of at least eight or ten quills, one placed inside of another. Cinnamon breaks with an uneven, somewhat fibrous fracture. Cassia, on the other hand, is a large, thick bark, the thickness usually exceeding 1½ mm, and is sometimes as high as 3 mm. Neither the outer nor inner layer in cassia is removed, and the outer corky layer is usually conspicuous. The pieces of cassia on the market never consist of one quill inside of another, as is the case with cinnamon, but are always single pieces, curved to form a crude circle. There is practically no ground cinnamon in the market. The best products that are sold for cinnamon are cassia.[1] Other adulterants are wheat and potato flours, sago meal, and the arrow root—all of which are usually baked—ground crackers, ground pease, and mineral matters, the most common form of which is probably red ocher. The volatile oil is also very commonly removed for flavoring extracts before the cinnamon is placed on the market. If a portion of ground cinnamon be boiled for a moment in water and cooled, iodin will not give a starch reaction, though an evident reaction may be obtained with cassia under the same circumstances. The composition of both cinnamon and cassia varies so widely that it is useless to adopt limits of analysis except, perhaps, in two or three items. The ash of cinnamon is from 3½ to 5 per cent, the soluble ash from 2 to 4 per cent, the volatile oil from 0.8 to 1.5 per cent. If the sample be adulterated with mineral matter this will, of course, be indicated by the high ash. If volatile oil has been removed, the small proportion of it may indicate the fact, though the natural percentage of that ingredient is so low as to render this criterion of doubtful value. With these exceptions the microscope must be used for the purpose of detecting adulteration, and the appearance of cinnamon and cassia, as well as of the substances that are used for their adulteration, is so characteristic that no difficulty is encountered in the microscopical examination.

CLOVES.

Unground cloves should consist of both calyx and corolla, the latter consisting of four petals closely imbricated into a globular bud. The calyx is a dark-brown color and the corolla is somewhat lighter. On scratching the corolla with a pin the volatile oil appears. When the oil has been removed the clove becomes almost black and its surface wrinkled and blistered.

Ground cloves are probably rarely sold in a pure state. The common adulterants are clove stems, allspice, flour, and burnt shells, as well as the adulterants that are used with other spices. The volatile oil is also frequently removed and the exhausted cloves put on the market either by themselves or after mixing with unexhausted samples. The limits of composition of cloves are:

	Per cent.
Mustard	3 to 10
Ash	5 to 13
Volatile oil	10 to 20
Non volatile ether extract	7 to 11
Fiber	6.5 to 9
Nitrogen	0.8 to 1.2
Oxygen equivalent	4 to 6

Tannin equivalent, 11 to 14 cc of tenth normal potassium permanganate.

The determinations which are of value in detecting the adulteration of cloves are volatile oil, fiber, nitrogen, ash, and tannin or oxygen equivalent. For the determination of the latter, 4 grams of the sample, previously extracted with absolute, alcohol-free ether, are placed in a 100 cc flask with 80 or 90 cc of water and digested over night at a temperature of from 90° to 95°. The mixture is then cooled to room temperature, diluted with water to 100 cc, thoroughly mixed by shaking, filtered, and titrated with a tenth normal solution of potassium permanganate, according to directions given in Bulletin 46, Division of Chemistry, United States Department of Agriculture, page 74.

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[1] The sale of ground cassia under the name of cinnamon should not constitute a form of adulteration, but "ground cinnamon" should be understood to mean the bark of any species of cinnamonum.

ALLSPICE OR PIMENT.

In flavor and composition, allspice closely resembles cloves, as would be expected from the fact that they are botanically very closely related. Being among the cheapest of the spices, however, it is not subject to such universal adulteration as is the case with many of the others. The adulterants commonly used are cocoanut shells, sandal wood, mustard hulls, ground husks, and clove stems, as well as those employed with other spices, and the volatile oil is frequently removed before the spice is placed upon the market. The limits of analysis are:

	Per cent.
Moisture	5.5 to 12
Ash	3 to 5
Volatile oil	2 to 5
Ether extract	7 to 13
Fiber	13 to 22

Tannin equivalent 5 to 7 cc of tenth normal potassium permanganate. The tannin is estimated according to the directions given under cloves.

NUTMEG.

Of all the spices nutmeg is probably the least subject to adulteration, since it is sold almost entirely in the unground state. It is said that artificial nutmegs have been prepared from mace, starchy material, and clay, or some other mineral matter, with the addition of a little nutmeg oil. If such imitations are really on the market they can readily be detected by the appearace of the cross section as viewed by the naked eye. The cross section of nutmeg has a marbled appearance, caused by narrow strips of the inner seed coat penetrating to the center of the seed.

MACE.

Mace is most commonly adulterated with what is known as "false" or Bombay mace. Other adulterants are turmeric and mineral substances, such as ocher and baryta. The microscopical appearance of mace is characteristic, and it requires but little practice for the observer to familiarize himself with the powder sufficiently to detect adulterants.

Bombay mace is very similar in structure to the true mace, but has a coarser structure, is of a much darker color, is odorless and tasteless. It is also said to be much higher in oil and ash, and its presence, as well as that of the other adulterants mentioned, may be detected from the chemical analysis. The limits of composition of mace are:

	Per cent.
Moisture	4.5 to 12
Ash	2 to 4
Volatile oil	5 to 9
Ether extract	30 to 40
Crude fiber	4.5 to 10
Nitrogen	0.7 to 1

Mace, like nutmeg, contains no fat. The extract, other than nonvolatile oil, consists almost entirely of resin. The presence of an adulterant containing less than 20 per cent of resin can be easily detected by the fact that true mace contains from 20 to 35 per cent of that substance.

CREAM OF TARTAR.

The most common adulterations met with in this substance are calcium sulphate, calcium carbonate, alum, acid phosphate of calcium, and starch. Calcium tartrate is found in nearly all tartars, but this can not be considered an adulterant, since its source is the argol from which the cream of tartar is manufactured. This impurity, however, should not exceed 10 per cent.

Qualitative examination.—This may be made as follows:

Free tartaric acid is tested for by treating a portion of the sample with alcohol. The filtrate from this is evaporated free from the alcohol and a test made for acid. This may be made a quantitative determination by titrating against a standard alkali solution.

Test for *phosphoric acid* in a nitric acid solution by adding ammonium molybdate solution. If sulphates be present, a hydrochloric acid solution of the ash should be tested for *aluminum.* If this be found, a test for ammonia in the original substance gives additional evidence of the presence of alum.

Earthy additions are left undissolved after treatment with a warm potassium hydroxid solution.

The washed residue is examined for carbonates, sulphates, calcium, barium, silica, etc. This operation may be made a quantitative one by drying and weighing the residues; if calcium sulphate be present, alcohol is added in considerable quantity before filtering and in the washing.

Starch.—From 2 to 5 grams of the substance are weighed into an Erlenmeyer flask and 150 to 200 cc of a 4 per cent hydrochloric acid solution added. The flask is provided with a stopper, and condensing tube 3 to 4 feet long. Boil gently for four hours, cool, neutralize with sodium hydrate, and make up to a definite volume. Determine the reducing power of an aliquot portion by methods given in Bulletin No. 46, Division of Chemistry, United States Department of Agriculture.

Phosphoric acid, aluminum, and calcium.—Weigh out 2 grams of the sample, incinerate, transfer to a 200 cc flask, and dissolve by boiling in 30 cc of nitric acid. Make up to the mark, and estimate phosphoric acid as in fertilizer analysis. Slightly alkalize the filtrate from the ammonium phosphomolybdate with ammonia, to precipitate the aluminum as hydrate. Heat and long standing should be avoided, else the molybdic acid will be precipitated. Filter, wash, ignite, and weigh as aluminum oxid. The calcium is precipitated from the last filtrate as the oxalate, ignited and weighed as the oxid. Or, the calcium may be determined by evaporating an aliquot part of the original nitric acid solution to a very small volume, with a little sulphuric acid, and then adding two to three times the volume of 95 per cent alcohol. Filter by means of a Gooch crucible, wash with alcohol, ignite a few seconds at low red heat, and weigh as calcium sulphate.

Total tartaric acid.—Weigh out 5 grams of the material and transfer to a 500 cc flask. Add 100 cc of water and 15 cc of strong hydrochloric acid. Make up to the mark and allow to settle. To 50 cc of the filtered solution add 10 cc of a solution containing 300 grams of potassium carbonate to the liter. Boil thirty minutes, filter into a porcelain dish, and evaporate to 10 cc. Add gradually, with constant stirring, 4 cc of glacial acetic acid and then 100 cc of 95 per cent alcohol, stirring until the precipitate appears crystalline. Allow to stand several hours, until the precipitate settles well, decant through a small filter, add alcohol, and wash the precipitate on the filter with alcohol until free from acetic acid. Transfer the filter and precipitate to a beaker, add water, and boil, washing out the dish with boiling water if any of the precipitate adhere to it. The resulting solution is titrated against a decinormal soda or potash solution, using phenolphthalein as an indicator. One cubic centimeter of the decinormal alkali corresponds to 0.0188 gram of potassium bitartrate or 0.015 gram of tartaric acid.

Calcium tartrate.—In the presence of other calcium salts, the powdered tartar is treated with warm potassium hydroxid solution, adding alcohol if the sulphate be present. The residue is washed on a filter, the filtrate neutralized with hydrochloric acid, and evaporated to a small volume. The calcium is precipitated with ammonium oxalate in the presence of a little free acetic acid. The calcium oxalate is collected and washed in a Gooch crucible and weighed as calcium carbonate, after gentle ignition, or as calcium oxid after complete ignition.

BAKING POWDERS.

These consist of bicarbonate of soda with some acidifying agent, usually bitartrate of potassium, acid phosphate of calcium, or alum. Tartaric acid is occasionally used for this purpose. These agents are mixed with some substance called "filling," which is usually starch, although flour is used sometimes. This filling checks deterioration in the strength of the powder, by preventing the acid and alkali from acting upon each other readily. Ammonium carbonate is sometimes used to increase the strength of the powder.

The impurities most commonly met with are calcium sulphate, calcium tartrate, and insoluble calcium phosphate. These are not called adulterations, since they are introduced with the ingredients of the powder.

QUALITATIVE TESTS.

Sulphates.—Sulphates are detected in an aqueous solution, in the absence of citric acid, by treating with barium chlorid and hydrochloric acid.

Ammonia salts.—Ammonia salts are detected in the cold-water extract by boiling with sodium hydroxid and testing the steam with moist, red litmus paper.

Phosphates.—Dissolve the ash in nitric acid and add ammonium nitrate and ammonium molybdate solution. Test for insoluble phosphates by boiling the powder with water. Then filter, wash, and dissolve the residue with hot nitric acid. Test solution for phosphates as above, page 126.

Alumina.—Dissolve the powder in very dilute nitric acid, add acetic acid and sodium phosphate. Or, fuse with potassium nitrate and sodium carbonate, extract with boiling water, and filter. Acidify the filtrate with hydrochloric acid, and precipitate the alumina with ammonia.

Tartaric acid and tartrates.—Free tartaric acid is dissolved out by absolute alcohol and identified. Tartrates are tested for by shaking the powder in ammonia, filtering, adding a crystal of silver nitrate, and gently heating to form a silver mirror.

It should be noted whether there be any considerable amount of residue insoluble in boiling water other than starch. If such be the case, its nature should be ascertained.

QUANTITATIVE DETERMINATIONS.

Available carbonic acid.—This is the most important estimation, as it determines the leavening strength of the powder. Place 1 gram of the sample in a dry alkalimeter containing 10 cc of water in the acid bulb. This is allowed to run into the powder slowly, after which it is gradually brought to the boiling point. Then the lamp is removed and the apparatus is aspirated thoroughly.

Total carbonic acid is determined in the same manner, except that 10 cc of dilute sulphuric acid are placed in the bulb instead of pure water.

Starch, phosphoric acid, tartaric acid, aluminum, and *calcium* are estimated the same as in the cream of tartar analysis. In case of phosphoric acid it is well to incinerate before dissolving in nitric acid.

Sulphuric acid.—Weigh 0.5 to 1 gram of the sample into a beaker and digest with strong hydrochloric acid until all goes into solution. Add barium chlorid, in slight excess, while still hot. Allow to stand twelve hours, filter, ignite, and weigh.

Potash and soda.—Weigh out 5 grams of the substance into a dish and incinerate at low heat. It is safer to add an excess of sulphuric acid before incinerating. With the aid of a little hydrochloric acid, transfer to a 500 cc flask, add water, and boil fifteen minutes. When cool, make up to the mark. One hundred cubic centimeters of the filtered solution are heated on a water bath, a slight excess of barium chlorid added, and then, without filtering, a slight excess of barium hydroxid. The precipitate is filtered off and washed. To the filtrate is added a little ammonium hydrate, and then ammonium carbonate until all the barium is precipitated. The precipitate is filtered off and washed and the filtrate is evaporated to dryness in a platinum dish, after acidifying with dilute sulphuric acid. The residue is thoroughly ignited and weighed as mixed sulphates of potassium and sodium. The potash is then determined in the residue by dissolving in hot water and hydrochloric acid, adding platinum chlorid, and proceeding in the usual way.

Ammonia is present either as the carbonate or as ammonia alum. It may be determined by distilling 1 gram of the sample with caustic soda. The distillate is received into an excess of standard acid solution and titrated back with a standard alkali solution. In case flour is used as a filling, which is not often, it must be separated from the ammonia salts by washing with water, and the ammonia determined in the filtrate.

A water solution of a baking powder should be about neutral; but in poorly made powders it is often alkaline. If such be the case, the free alkali should be determined by titration.

VINEGAR.

The adulterations most frequently met with in vinegar are water, pyroligneous acid, mineral acids, usually sulphuric or hydrochloric, caramel, and other coloring matters.

Cider vinegar usually contains from 3.5 to 6 per cent acetic acid, 1.5 to 2.5 per cent solids, and has a density usually given from 1.013 to 1.016 at 15° C., but it often goes far beyond these limits. The dried residue has the odor of baked apples, contains malic but no tartaric acid, and gives slight precipitates with barium chlorid, silver nitrate, and ammonium oxalate.

Wine vinegars run high in acetic acid and density, and have from 1.7 to 2.5 per cent solids. The extract, treated with alcohol, leaves a granular residue of acid tartrate of potassium. The average amount of this salt is about 0.25 per cent. Its presence is peculiar to wine vinegars.

Beer and *malt vinegars* have a high density, ranging from 1.021 to 1.025, and a high percentage of solids, from 5 to 6 per cent. They also contain a high percentage of phosphates, and considerable quantities of sulphates and chlorids.

The specific gravity is determined by a Westphal balance, or a picnometer, at a temperature of 15° C.

The acidity is determined by titrating against a decinormal sodium hydroxid solution, using phenolphthalein as indicator. The result is calculated to percentage of acetic acid.

Free mineral acids.—A solution of logwood is prepared by pouring 200 cc of boiling water on 2 grams of logwood chips and allowing to stand for a few hours before filtering. Dry a drop of this solution on a porcelain surface, add a drop of the vinegar to the residue and dry again. The presence of a mineral acid imparts a red color to the residue. If the proportion of mineral acid be very small, the red color is destroyed by the addition of water, but is restored on reevaporation unless nitric acid is present. If mineral acids be present, add enough sodium hydroxid solution to 50 grams of the solution to neutralize the mineral acids, but not enough to render the liquid alkaline. Evaporate and carefully ignite. Titrate back with standard acid. The difference in the amounts of alkali and acid used is the amount neutralized by the free mineral acids.

Free sulphuric acid.—Evaporate 100 grams of the sample to a small volume; cool; add four to five times its volume of alcohol. Sulphates are precipitated and free sulphuric acid remains in solution. Filter; wash the precipitate with 80 per cent alcohol; boil off the alcohol from the filtrate after dilution, and precipitate the sulphuric acid as barium sulphate.

Solids.—Evaporate 10 grams of the sample to dryness on a steam bath and then dry to a constant weight at 100° C.

Ash.—Burn solid residue at dull red heat. Test the ash, after moistening, with litmus. If it be neutral, free mineral acids are probably present in the sample. If it be alkaline none can be present.

Phosphoric acid.—Dissolve the ash in nitric acid, filter, and add a few crystals of ammonium nitrate. When these are dissolved, add about 25 cc of the clear ammonium molybdate solution used in fertilizer analysis. Digest, with occasional stirring, for thirty minutes in a warm place, not allowing the temperature to rise above 65° C. Let stand one hour in the cold and filter through a weighed Gooch crucible. Wash with water slightly acidulated with nitric acid. Dry thirty minutes at 105° to 110° C. and weigh. Calculate the percentage of phosphoric acid by the use of the factor 0.0367.

CANNED FOOD.

The practice of preserving various kinds of food in hermetically sealed receptacles has become so common that far more attention should be given to canned food which is on the market than it receives at the present time, and methods for its examination should be adopted. The appearance of the cans themselves should first be noted. The ends should be slightly concave, since the contents are sterilized by means of heat and a contraction of volume must necessarily follow cooling. If the ends of the can be convex, some decomposition is indicated. In the case of bottled goods, the pressure on the cork should be observed since even the slightest pressure tending to expel the cork is an indication that some decomposition has taken place after the goods were put up. Marked corrosion on the inside of the can is often an indication of the presence of metals in solution. No food which is capable of corroding metal receptacles should be preserved in them. In canned corn, corrosion may be sometimes due to the presence of sodium sulphite, which is added for the purpose of bleaching the corn. In such cases dark nodules of tin sulphid are also found at the edge of the can.

Any sample of canned goods which has an alkaline reaction with litmus paper is to be regarded with suspicion.

Among the various classes into which canned food may be divided are meats, meat extracts, fruits, vegetables, and catsups. The most common adulterants, perhaps, are added for the purpose of better preserving the food, and are treated of in some detail under the head of preservatives. To prepare a sample of canned food in such a manner that the methods given for detection of preservatives may be applicable, from 50 to 200 grams of the sample, previously ground, if necessary, are mixed in a mortar with enough water to give the proper degree of fluidity.

Coloring matter is also very commonly used, especially with food of a marked red or green color, such as tomatoes, catsups, some varieties of meat, peas, beans, and pickles. The salts of several metals are often present, sometimes having been added intentionally, at other times due to carelessness or the use of improper receptacles. Among these metals the most important are copper, lead, tin, and zinc. A slight amount of copper may be normal to many vegetables. A somewhat larger amount may come from the use of copper utensils; but if the utensils be kept clean, and ordinary care exercised in the preparation of the food, only a slight amount of the metal will be introduced in this way. The presence of more than 10 mg of copper per kilogram of the food may be taken as sufficient evidence that copper has been intentionally added. This practice is only resorted to for the purpose of giving a marked green color to foods to which a portion of the public has been educated to ascribe a green of unnatural brightness, especially peas, beans, and cucumber pickles. Zinc has in a few cases been added for the same purpose, but its use as an agent in preserving the coloring matter has not become at all general. Its presence in canned food is very common, but is almost always due to its use as a flux in soldering.

Lead comes from the use of inferior tin plate or, more commonly, solders which are much too soft. The tin plate employed should be almost free from lead, and solder which is exposed to the contents of the can should contain less than 10 per cent of lead. Owing to the lack of legislation on the subject in this country, however, the solders commonly used by our canners contain from 40 to 60 per cent of lead, and not only is a large amount of this solder exposed to the contents of the can in the seams, but it often happens that one or more pellets of the size of bullets are found loose in the can.

Tin is frequently dissolved from the tin plate by strongly acid foods. It is probable that the amount of tin sulphid is much greater where the soldering or plate exposed to the contents of the can, contains a large percentage of lead. It has been suggested that this is due to electrolytic action.

In examining a sample of canned goods for heavy metals, it should first be dried at the temperature of boiling water and charred in a porcelain dish at the lowest possible temperature. The soluble compounds may then be removed by washing the char with a few cubic centimeters of dilute nitric acid and filtering. The char and filter are then ignited, and the residue, dissolved in a little dilute nitric acid, added to the filtrate from the char. The ordinary qualitative and quantitative methods for the metals enumerated may then be applied to the solution.

WINES.

The practice of adulterating wines is so common and the methods of adulteration have been studied so long and so carefully that the detection of the adulterants used is often attended with the greatest difficulty.

The composition of dry wines and sweet wines, calculated to sugar-free substances, should not vary far from the following figures:

Composition of wines.

Constituents.	Grams per 100 cc.	
	Red.	White.
Alcohol, by volume	12.0	11.50
Extract, less sugar	2.80	2.00
Total acidity	.50	.55
Tannin and coloring matter	.25	.96
Ash	.28	.20

These figures are for young wines. After standing two or three years, the percentage of extract will decrease about 10 per cent. Wines should be regarded with suspicion which contain less than 2.4 grams of extract or more than 3.2 grams per 100 cc, or which contain less than 0.2 gram of ash or more than 0.35 gram per 100 cc, whose total acidity is less than 0.45 gram HCl per 100 cc, whose ash is less than one-eighth or more than one-half of the sugar-free extract, whose sulphuric acid calculated to potassium sulphate is over 0.2 gram per 100 cc, and whose chlorin calculated to sodium chlorid is over 0.2 gram per 100 cc.

With American wines, the presence of volatile acid, calculated to acetic acid, in excess of one-fourth of the total acid may be considered almost certain evidence of adulteration, though with European wines the ratio is somewhat larger. Wines sometimes contain an appreciable amount of copper, lead, and zinc, and sometimes, though rarely, traces of arsenic are found, owing to the use of crude glucose and anilin dyes for the purpose of coloring. Copper, lead, and zinc may be detected as directed under canned foods. For the detection of arsenic, the extract should be digested with 2 cc of sulphuric acid and about 25 cc of nitric acid to destroy the organic matter, heated with sulphuric acid until nitric fumes are entirely expelled, and the residue examined with the Marsh apparatus.

Methods for the detection of preservatives are given on page 132.

DETECTION OF COLORING MATTER.

First method.—Add 0.2 gram of precipitated mercuric oxid to 10 cc of wine; shake for one minute and filter.

Pure wines give filtrates which are colorless or light yellow, while the presence of a more or less red coloration indicates that an anilin color has been added to the wine.

Second method.—Evaporate the alcohol from 200 cc of wine, add 2 to 4 cc of a 10 per cent solution of hydrochloric acid, immerse some threads of fat-free wool, and boil for five minutes. Remove the threads, wash them with cold water acidified with hydrochloric acid, then with hot water acidified with hydrochloric acid, then with pure water, and dissolve the color in a boiling mixture of 50 cc of water and 2 cc of concentrated ammonia. Replace the threads with new ones, acidify with hydrochloric acid, and boil again for five minutes. In the presence of anilin colors to the amount of 2 mg per liter, the threads are dyed as follows:

Safranin	light rose red.
Vinolin	rose red to violet.
Bordeaux red	rose red to violet.
Ponceau red	rose red.
Fuchsin	dirty white.
Tropæolin 00	straw yellow.
Tropæolin 000	light orange.
Corallin	dirty white.

This method is not suitable for the detection of fuchsin or corallin.

Detection of fuchsin and orseille.—To 20 cc of wine add 10 cc of lead acetate solution, heat slightly, and mix by shaking. Filter into a test tube, add 2 cc of amyl alcohol and shake. If the amyl alcohol be colored red, separate it and divide it into two portions. To one add hydrochloric acid, to the other ammonia. When the color is due to fuchsin, the amyl alcohol will in both cases be decolorized; when due to orseille, the ammonia will change the color of the amyl alcohol to purple violet.

BEER.

Beer is made by fermenting the aqueous extract of malted barley, after the addition of hops. In some countries, there is legislation providing that beer shall be manufactured exclusively from malt, hops, and water. In this country, however, the use of certain malt substitutes is considered legitimate. If unmalted barley be employed as a malt substitute, or any other cereal whose content of insoluble albuminoids is equal to that of malt, the food value of the beer is probably not decreased. If dextrin, starch, or rice be employed, however, the content of albuminoids will be materially reduced. The important determinations for judging of the quality of the beer or of its adulteration are alcohol, specific gravity, glycerin, ash, sulphuric acid, sulphurous acid, phosphoric acid, and chlorin. It is also essential to examine qualitatively for the presence of preserving agents and saccharin. The methods for the detection of the presence of the last two named are given under appropriate headings. Hydrochloric acid may be determined in the nitric-acid solution of the ash, by any of the well-known gravimetric or volumetric methods. The other substances named may be determined by the methods given under the adulteration of wine. The glycerol content of beer should not be less than 0.4 gram per 100 cc. The ash should not be less than 0.12 nor greater than 0.30 gram per 100 cc. The presence of less than 0.10 gram indicates that some malt substitute which is low in ash, such as starch, has been used in the preparation of the beer, while if the ash content be greater than 0.30 gram per 100 cc, and the volatile acids, calculated to acetic acid, less than 0.075 gram per 100 cc, it is probable that an excess of acid has been neutralized by sodium carbonate, and the ash of the beer should be examined for both sodium and carbonic acid. The presence of phosphoric acid should not be less than 0.05 gram nor greater than 0.10 gram per 100 cc. If less than 0.05 gram, it is probable that a portion of the malt has been replaced by starch or some similar substance. In European countries, hop substitutes are said to be frequently employed. Their presence has never been noticed in American beers, however, and the low price of hops makes it entirely improbable that substitutes are to be found in American beers.

CIDER.

Cider is the juice of the apple, either fresh or partially or wholly fermented, but without the addition of any other substance. The composition of cider is—

Composition of cider.

Constituents.	Grams per 100 cc.
Alcohol	Below 7
Extract	2 to 8
Sugar	0.4 to 4
Total acidity, calculated to H_2SO_4	0.2 to 0.5
Fixed acids, calculated to H_2SO_4	0.1 to 0.27
Ash	0.17 to 0.35
Potassium carbonate	0.14 to 0.23

The adulterations to which cider are subjected in this country are dilution with water and the addition of alkali to correct acid fermentation, and especially the addition of preservatives. The percentage of alcohol increased by 49 per cent of the content of sugar and 97 per cent of the content of volatile acid, calculated to acetic acid, should not be less than 3 nor greater than 9. The percentage of extract should be from 2 to 8, including sugar, and obviously, if the percentage of alcohol be high the percentage of sugar will be correspondingly low. The presence of less than 1.7 per cent of ash may be taken as evidence of dilution with water, while if the percentage of ash be greater than 3.5 it is probable that a carbonate has been added for the purpose of neutralization.

PRESERVATIVES.

The methods given below for the detection of preservatives are applicable to liquids only. If it be desired to apply them to solid or semisolid substances, it will be necessary to grind these in a mortar with water until a sufficient degree of fluidity is obtained. It may sometimes be necessary to macerate the substance in some way before it can be ground in the mortar.

SALICYLIC ACID.

First method.—Shake about 100 grams of the sample, after adding 5 cc of dilute (1:3) sulphuric acid, with 25 cc of chloroform. Allow to stand over night, remove the clear filtrate (not the emulsion) by means of a pipette, and evaporate to dryness at a low temperature. Take up with 2 or 3 cc of water, filter into a clean porcelain dish, and test with a few drops of a 0.5 per cent solution of ferric chlorid. The formation of a marked purple or violet color is sufficient evidence of the presence of salicylic acid.

Second method.—Acidify 100 cc of the liquor with sulphuric acid and extract with sulphuric ether. Evaporate the extract to dryness, warm the residue carefully with 1 drop of concentrated nitric acid, and add 2 or 3 drops of ammonia. The presence of salicylic acid in the liquor is indicated by the formation of the yellow color of ammonium picrate, and may be confirmed by dyeing a thread of fat-free wool.

Third method.—Place 100 cc of the wine in a separatory funnel, add 5 cc of sulphuric acid (1:3), and extract with a sufficient quantity of a mixture of eight or nine parts of ether to one part of petroleum ether. Throw away the aqueous solution, wash the ether once with water, then shake thoroughly with about 50 cc of water, to which from 6 to 8 drops of 0.5 per cent solution of ferric chlorid have been added. Discard the aqueous solution, which contains the greater part of the tannin in combination with iron, wash again with water, transfer the ethereal solution to a porcelain dish, and allow to evaporate spontaneously. Then heat the dish on the steam bath, take up with 1 or 2 cc of cold water, filter into a test tube, and add 1 or 2 drops of 0.5 per cent solution of ferric chlorid. The presence of salicylic acid is indicated by the appearance of a violet-red coloration. In the case of red wines a second extraction of the residue with ether mixture is sometimes necessary. This is determined by the color of the residue left in the dish on the evaporation of the ether.

This method can not be used in the examination of beers and ales.

Fourth (Girard's) method.—Extract a portion of the acidified liquor with ether as in the preceding methods, evaporate the extract to dryness, and extract the residue with petroleum ether. The residue from the petroleum ether extract is dissolved in water and treated with a few drops of a very dilute solution of ferric chlorid. The presence of salicylic acid is indicated by the appearance of a violet-red coloration.

BENZOIC ACID.

First method.—Benzoic acid is used for the preservation of a large variety of foods. It is probably the preservative most commonly used with catsups and preserves.

Extract from 100 to 200 grams of the sample by any of the methods given under salicylic acid, evaporate the ether or chloroform extract to dryness, take up the residue with 8 or 10 cc of water, filter, neutralizing the filtrate as exactly as possible with a dilute solution of sodium hydroxid, being careful not to add the sodium hydroxid in excess, and treat with a few drops of a 0.5 per cent solution of ferric chlorid. The presence of benzoic acid will be indicated by the formation of a voluminous brownish-colored precipitate of ferric benzoate.

Second method.—Five hundred cubic centimeters of the sample are distilled almost to dryness after the addition of 20 cc of sirupy phosphoric acid. The distillate is then extracted with several successive portions of ether and the ethereal solution treated by Mohler's method.

The details are as follows: Evaporate off the ether from the resulting extract, and treat the residue with 2 or 3 cc of strong sulphuric acid. Heat till white fumes appear. Organic matter is charred and benzoic acid is converted into sulphobenzoic acid. A few crystals of potassium nitrate are then added. This causes the formation of metadinitrobenzoic acid. When cool the acid is poured into water and ammonia added in excess, followed by a drop or two of ammonium sulphid. The nitro compound becomes converted into ammonium metadiamidobenzoate, which possesses a peculiar reddish-brown color. This reaction takes place immediately and is seen at the surface of the liquid without stirring. Salicylic acid will sometimes give the same reaction, but only after waiting some minutes. The benzoic acid must first be separated in a state of approximate purity before this test can be applied. Half a milligram of the acid can be detected in the absence of interfering bodies.

FLUORIDS.

The use of fluorids as antiseptics is now becoming quite common, especially for the preservation of wines. One hundred grams of the sample, made slightly alkaline with ammonium carbonate, are heated to boiling and the fluorin precipitated with a few cubic centimeters of calcium chlorid solution. The boiling is continued for five minutes after the precipitation, the precipitate removed by filtration, washed with a little water, dried, and ignited in a small platinum crucible. One cubic centimeter of strong sulphuric acid is added, and the crucible is covered with a watch glass coated with beeswax (marked in such a way as to permit it to be etched at some point) heated on a water bath for an hour at a temperature of from 75° to 80°. One mg per kg can be readily detected by this method.

BORIC ACID.

First method.—Boric acid and borax have long been used for the preservation of many articles of food, especially milk and meats. A great many preservatives are placed on the market which consist especially of boric acid, either free or combined. For the detection of boric acid, from 50 to 100 grams of the sample are made alkaline with sodium hydroxid or lime, dried, and thoroughly ignited. The ash is acidified with hydrochloric acid, a drop of turmeric tincture added, and the dish placed on the steam bath. The presence of boric acid imparts a cherry-red color which is unmistakable, even when present in very small quantities. It is best, however, to always conduct a blank experiment, as a pale-brown color is commonly given by the reagents themselves.

Second method.—Another method is to make 100 grams of the sample alkaline with sodium hydroxid or lime, evaporate to dryness, and incinerate as given above. Digest the residue in a few drops of dilute sulphuric acid, add 3 or 4 cc of alcohol, transfer the mixture to a platinum crucible, placing the cover in such a position that a small opening is left, and heat gradually and gently until the alcohol distills and may be burned from the opening that is left at the top of the crucible. The presence of boric acid is indicated by a green flame. If sufficient care has been exercised in the distillation, the flame will be free from the influence of sodium or calcium, and the green boric-acid flame may be recognized even if but traces of the substance be present.

ALKALINE FLUOBORATES AND FLUOSILICATES.

These preservatives are frequently overlooked in the examination of foods, as at low temperature they are decomposed, volatile compounds being formed. For their detection 200 grams of the sample are made alkaline with lime water, evaporated to dryness, and incinerated. The ash is treated with water slightly acidified with acetic acid and filtered. The filtrate may be examined as directed under "Boric acid" and the precipitate as directed under "Fluorids."

PHENOL DERIVATIVES.

Several compounds closely related to and derived from phenol and naphthol have been used for the preservation of fats to some extent, although their use is by no means common. Two hundred grams of the sample are acidified with dilute sulphuric acid and distilled with steam. The first 200 cc of the distillate are extracted in a separatory funnel with 15 or 20 cc of chloroform. The chloroform is separated, rendered slightly alkaline with potassium hydroxid, and heated almost to boiling for a few minutes. The presence of a compound belonging to the class mentioned will be shown by a marked color. Phenol becomes light red, changes to brown, then bright yellow, and finally colorless. O-cresol takes on a lilac color with a tinge of orange. β-naphthol gives a deep Prussian blue, changing to green, and finally to brown. Salol takes on a light-red color.

SULPHITES.

Sulphites are very often added to wine for the double purpose of bleaching and preserving. Since the sulphuring of the casks is a common practice and is allowable, it is a very difficult matter and often impossible to tell whether the sulphurous acid is due to the sulphuring of the cask or to the addition of a sulphite. The only way to control the matter is to prescribe an allowable limit for the amount of sulphurous acid present. It may be detected as follows, and should not exceed 80 mg per liter:

One hundred cubic centimeters of wine are distilled in a current of carbon dioxid, after the addition of phosphoric acid, until about 50 cc have passed over. The distillate is collected in accurately standardized iodin solution. When the distillation is finished, the excess of iodin is determined with standardized sodium thiosulphate solution, and the sulphurous acid calculated from the iodin used.

ABRASTOL OR ASAPROL.

Abrastol has been suggested for the preservation of food, and is said to have been used to some extent for this purpose in Europe. Its use in this country has not become general, however, and it is quite probable that it does not occur in American foods at all. Bellier's method is probably the most delicate that has yet been suggested for its detection.

Fifty cubic centimeters of the sample are made alkaline with a few drops of ammonia, gently shaken for two minutes with 10 cc of amyl alcohol (alcohol is added if an emulsion be formed), the amyl alcohol is decanted, filtered if turbid, and evaporated to dryness. The residue is thoroughly moistened with 2 cc of a mixture of equal parts of strong nitric acid and water, heated on the water bath until half of the water is evaporated, and transferred to a test tube with the addition of 1 cc of water. About 0.2 gram of ferrous sulphate are now added, and then an excess of ammonia, drop by drop, with constant shaking. If the resulting precipitate be of a reddish color, it is dissolved in a few drops of sulphuric acid, and ferrous sulphate and ammonia are added as before. As soon as a dark-colored or greenish precipitate has been obtained 5 cc of alcohol are added, the precipitate is dissolved in sulphuric acid, and the fluid is well shaken and filtered. In the absence of abrastol this method gives a colorless or light-yellow liquid, while a red color is produced in the presence of 0.01 gram of abrastol. The author states that the method is applicable to the examination of wine, beer, sirups, and preserved food.

Fats should first be melted, extracted with hot 20 per cent alcohol, the filtered alcohol evaporated to dryness, and the residue treated as given above. Salicylic acid gives a more orange-colored liquid when treated in the same manner, and when this liquid is treated with a few drops of a very dilute ferric chlorid solution the well-known violet reaction is produced, while abrastol gives a blue color with ferric chlorid, which disappears on heating. The natural coloring matter is not extracted from the alkaline liquid by amyl alcohol, and anilin colors may be removed by evaporating to dryness with wool, in the presence of acetic acid or ammonium hydroxid, according to the nature of the coloring matter, when water will dissolve only the abrastol.

FORMALDEHYDE.

Distill about 100 grams of the prepared sample until the distillate measures about 20 cc. The distillate, after the addition of one or two drops of a 1 per cent aqueous solution of phenol, is poured carefully on concentrated sulphuric acid in a large test tube. The presence of even a trace of formaldehyde is indicated by the formation of a crimson color at the plane of union of the two liquids, while, if the preservative be present in greater quantity, a white turbidity, or even a light-colored precipitate, is formed above the red ring.

RECOMMENDATIONS.

The referee would recommend—

(1) That the report be referred to a committee, to be appointed, who shall examine it in detail, paying special attention to the standards which are given, and report in time to have the methods printed in the forthcoming bulletin.

(2) That the referees for the ensuing year pay some attention to the determination of starch in spices. Where they are adulterated by starch products, it has been found possible, even by direct conversion with hydrochloric acid, to detect such

adulterations. It is probable that the use of a modern method would afford a much better criterion.

Also that the referees for next year pay further attention to standards not covered by the referees of this year and to methods for the examination of some substances not taken up by the present referee.

(3) That the title of the referee be changed to "Referee on food adulterants."

THURSDAY—AFTERNOON SESSION.

Called to order by the president at 2.15 p. m.

The chair called for the report of the committee on abstracts, which were read by the chairman of the committee, Mr. Allen.

REPORT OF COMMITTEE ON ABSTRACTS.

Mr. President and Members of the Association.

GENTLEMEN: Your committee has the honor to report that its work during the past year has been conducted on the same general plan as in the previous year. After ascertaining the journals accessible to each member of the committee, an assignment of work was made which was intended to be as nearly equitable as the circumstances would permit. The list of journals for which the different members of the committee have been responsible the past year is as follows:

E. W. Allen: Jour. f. Landw.; Landw. Vers. Stat.; abstract part of Chem. Centbl., Analyst, Chem. Ztg., Jour. Chem. Soc., Ztschr. analyt. Chem., and Ztschr. angew. Chem.; and experiment station publications.

J. T. Anderson: Chem. Ztg.; Jour. Lond. Chem. Soc.

W. D. Bigelow: Bull. Assn. Belge des chim.; Forsch. über Lebensmtl.; Rev. intern. Falsif.; Ztschr. physikal. Chem.

B. H. Hite: Ann. chim. et phys.; Monit. Scientif.; Rev. chim. analyt.

B. W. Kilgore: Analyst; Chem. News; Ztschr. analyt. Chem.

W. H. Krug: Papers on sugar published in the German language.

F. W. Morse: Jour. Amer. Chem. Soc.; Ztschr. anorgan. Chem.; Ztschr. angew Chem.

H. J. Patterson: Amer. Chem. Jour.; Boston Jour. Chem.; Jour. Soc. Chem. Ind.; Science News.

F. W. Woll: Milch Ztg.; Ztschr. Nahr. Untersuch. und Hyg.; Ztschr. physiol. Chem.

The publication of the abstracts began in Experiment Station Record, volume 8, No. 4, and has continued quite regularly through the year up to volume 9, No. 3, which is now in press. The printed work of the committee has occupied about 70 pages. Besides the articles which have been abstracted at considerable length, a large number of papers have been noted briefly or by title merely. In most lines it is believed that the field has been covered in a general way and the work is well up to date.

As in the previous year, the work of the abstract committee has been supplemented by Mr. W. H. Beal, of the Office of Experiment Stations, to whom acknowledgment is here made.

E. W. ALLEN,
J. T. ANDERSON,
W. D. BIGELOW,
B. H. HITE,
B. W. KILGORE,
W. H. KRUG,
F. W. MORSE,
H. J. PATTERSON,
F. W. WOLL,
Committee.

Upon motion the report was accepted.

The chair called for the report of the committee on volumetric standards, which was read by Mr. Kilgore.

REPORT OF COMMITTEE ON STANDARDS FOR VOLUMETRIC APPARATUS, STANDARD TEMPERATURES FOR SPECIFIC-GRAVITY DETERMINATIONS, ETC.

In view of the numerous methods in use by the manufacturers of chemical glassware, for the calibration and graduation of volumetric apparatus, it seems proper that this association, in collaboration with the other scientific bodies of this and other countries, take up the work of bringing about uniformity in the apparatus offered for sale by dealers and in obtaining legislation, if necessary, to insure the marking of all measuring vessels and instruments in a manner that will clearly indicate the system of graduation used, in the case of each individual piece of apparatus.

This subject has been carefully studied in Europe for several years, and several reports have been made by German chemical societies and by committees of the international congresses of applied chemistry which have been held in Brussels and Paris during recent years. The imperial bureau of weights and measures of Germany has taken up the matter, and has minutely defined the conditions under which it works, in testing apparatus submitted for that purpose. A scale of fees has already been established for the testing of apparatus and the placing of the official stamp thereon. A committee is to report on this subject to the next Congress of Applied Chemistry, to be held in Vienna next year.

We therefore make the following recommendations:

(1) That this association adopt, at the earliest moment practicable, a definite system for the graduation of all chemical measuring instruments, including accurate definitions of the basis of graduation, form, and limits of accuracy of each class of apparatus.

(2) That an invariable standard unit of volume be adopted. For this standard we recommend the true liter (the volume occupied by 1,000 grams water at 4° C., weighed in vacuum) and the decimal divisions thereof, which have already been adopted by the International Congress of Applied Chemistry held in Paris in 1896. This is the only invariable and truly scientific unit of volume.

(3) That the members of this association, whenever they make purchases of laboratory supplies in the future, insist upon having apparatus graduated upon this system; also that members of the association having college duties use this system, whenever possible, in their class work.

(4) That the members of this association observe the temperature of their laboratories during working hours, in order to arrive at the best temperature for the calibration of volumetric apparatus for use in their own laboratories and for general use in this country.

(5) That a committee be appointed to take steps to secure the cooperation of other scientific bodies in this work.

(6) That there be printed in the proceedings of this association translations of the requirements for measuring instruments adopted by the Deutsche Gesellschaft für angewandte Chemie in 1891 and published by the German bureau of weights and measures in 1893.[1]

(7) That the results of all determinations of specific gravity, whenever practicable, be expressed in terms of water at 4° C.—that is, that the specific gravity of the substance be regarded as the weight in grams of 1 true cubic centimeter of the substance, at the temperature at which the determination is made.

B. W. KILGORE, *Chairman.*
C. L. PENNY.
E. E. EWELL.

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[1] For this translation, see Appendix.

DISCUSSION OF STANDARDS.

Mr. Patrick moved that the report be accepted and adopted.

Mr. KILGORE. To some members of the association who have not thought a great deal about it, this may not seem an important matter. But when we consider the two systems of volumetric units upon which our glassware is graduated and the differences that may arise when we make up solutions in apparatus graduated on one system, and use them in burettes graduated on the other, it is a matter of the greatest importance. There are two systems in use, the Mohr liter and the true liter. If part of our apparatus be graduated upon the Mohr system and part upon the true liter we may have trouble. It appears to the committee that the true liter is the only invariable standard, and that it would be well for this association, in conjunction with the other scientific bodies of the country, to recognize this as the true volume and insist upon having all our apparatus graduated upon this system. The main advantage claimed for the Mohr system is that at 17.5° a liter flask is placed upon the balance and 1,000 grams of water weighed without making any correction. It is, however, a very simple matter to make the calculation for a correction that would make it the truth instead of the estimation it is.

One other point we desire to call attention to is the temperature to be used in marking this volumetric apparatus. Now we have apparatus marked on the Mohr system at 15° C., though his first temperature was 17.5° C. There is quite a little difference in a liter flask graduated for water at 15° and 17.5° C.; there is an expansion of about 0.06 cc. It is possible, therefore, for large errors to creep into the work on this account. We think it is possible for the members of this association, by observing the temperatures of their laboratories, to come to a uniform standard of temperature at which we can have all our apparatus marked. Seventeen degrees is too low, and 21° or 22° C. would come nearer working conditions. By a long system of experiments, I have found, in our laboratory, that the average temperature for the working time of the day is 21.8° C. We do not think it wise to take any action in this matter now, but leave it for observation in the different laboratories, and if we can come to some understanding as to the temperature at which we can have our apparatus graduated, it will be a great advantage.

The Chair called attention to the fact that the pending motion was for the acceptance and adoption of the report, and questioned whether the word "approved" should not be used instead. The matter, he believed, would come up before the International Congress of Chemists at Vienna shortly, and if this were so it might be well for the association, without taking final action, simply to approve the general recommendation, leaving the adoption to wait upon the action of the international congress, but continuing the committee or appointing another to see that the general recommendation of the association be registered with the Congress of Chemists at Vienna.

Mr. **Kilgore**. That was the object of the committee, not to ask for any definite action from the association in recognizing any standard, but merely to bring the matter before it in a way that would help to bring about an international standard. All we ask is that the report be approved and accepted and the matter go over.

Mr. Patrick thereupon withdrew his motion and moved simply that the report of the committee be accepted. Carried.

Mr. Winton moved that the committee on volumetric standards be continued for another year, since its work could not be completed before the European committees reported, and before the association could take final action on the matter it would be necessary to have the committee report again to the association. He also moved that the committee be enlarged from three to five. Seconded and adopted.

The chair later appointed Messrs. Wiley, of Washington, and Caldwell, of Cornell, the additional members of this committee.

RECOMMENDATIONS AS TO DAIRY PRODUCTS.

Mr. **Bartlett**. The first four recommendations of the referee on dairy products are approved by the committee. They are as follows:

The committee recommends—

(1) That the provisional method for determining casein in cow's milk be made official, inserting in line 3 (Circular No. 2, Department of Agriculture), after "add," the following words: "One part of formaldehyde to 2,500 parts of milk," and in the first line of the second paragraph substitute the word "preservatives" for "mercuric chlorid."

(2) That the modified provisional method for determining albumin in cow's milk be substituted as a provisional method for the present provisional method, and that further cooperative work be done on the determination of albumin.

(3) That the magnesium sulphate method for determining casein in cow's milk be made an official optional method.

(4) That under milk (*a*) (Bulletin No. 46) the phraseology of the first and second sentences be changed to read as follows: "Heat to constant weight from 1 to 2 grams of milk in a tared flat dish, having a diameter of not less than 5 centimeters, containing 15 to 20 grams of pure dry sand, or without sand, at the temperature of boiling water."

DISCUSSION OF FOOD ADULTERATION.

Mr. **Bartlett**. The committee recommends that the report of the referee on food adulterations and standards of purity and the whole subject of food adulterations, including dairy products, be referred to a committee of five, to be appointed by the incoming president, such committee to have subcommittees, and to refer methods and standards to the next meeting of the association.

Mr. **Bigelow**. I think probably we might make a little better time than that and get some of the methods into the next bulletin. I think a committee of five would be rather cumbersome; probably a committee of three would act with more facility. I would move to amend the recommendation of the committee and substitute for it that a committee of three be appointed by the chair to examine the methods and standards reported, modify them as may seem best, and have the report printed in the coming edition of methods of analysis.

Mr. SCOVELL. It was not the intention of the committee to exclude this referee's report from the publication, but we did not wish to adopt any system until this committee reported it. It was the intention to have a committee appointed which would be broad in its scope and have the whole subject of food, especially as to standards, submitted to the next convention. The report of the referee will be included in the proceedings.

Mr. VAN SLYKE. In the adoption of standards for the purity of food stuffs, I think we ought to proceed with caution. If the association adopt standards they will be made use of in the courts of the different States. If we make a mistake we shall do an injury, because our work will be referred to by one side or the other, and if in the suggestion of a standard we make an error, then somebody will make use of it to our injury as well as to the injury of the trade in which that particular product may be found. My feeling is that in the end the best interests of all would be subserved by letting the matter simmer in the hands of a desirable committee for another year.

Mr. HUSTON. There seems to be a little misunderstanding here. I understand that the referee on this subject keeps the same relative position that any other referee does. He deals with the technical work relating to the subject of foods and food adulterants, methods of detection, etc. Now, as I understand it, this committee is to cover more general matters relating to the subject, including whatever action may be necessary relative to legislation, and possibly the passing upon standards for comparison. It seems to me there is a good field for such a committee, and that if drawn from different sections of the country it can be very valuable in this matter, for there are widely varying conditions in even raw material that enters into food products in different sections of the country. I do not understand that this committee is to take the place of the referee at all. I think we should proceed with caution, and that a good, strong, conservative committee can be of service.

Mr. WHEELER. I think we have had points enough to show that this association should proceed slowly in the matter, and time be given for the adoption of standards to which we can adhere in the future. For that reason I hope the amendment will be defeated.

The amendment was lost. The Chair then put the original motion on the adoption of the recommendation, which was carried.

The president-elect, Mr. Winton, appointed the following gentlemen as members of the committee, viz: H. W. Wiley, chairman; H. A. Weber, Columbus, Ohio; M. A. Scovell, Lexington, Ky.; E. H. Jenkins, New Haven, Conn.; William Frear, State College, Pa.

RECOMMENDATIONS ON PURE FOOD AND SOIL ANALYSIS.

Mr. **Bartlett**. (Referring to the committee on pure-food legislation.) The committee recommends that this association approve the recommendations of the committee on pure-food legislation, approve the bill as drawn by the committee, that the committee be continued and authorized to transmit the bill to the proper committees of the National House of Representatives and Senate with the indorsement of this association, and urge speedy action along the lines mentioned.

Adopted, and the committee continued with powers as described.

Mr. **Bartlett**. (Referring to the recommendations of the referee on soil analysis.) The committee recommends that his first recommendation, that the ammonium and calcium chlorid methods be further investigated next year, be approved.

Adopted.

Mr. **Bartlett**. (Referring to the recommendation of the referee on soil analysis, that the one-fifth normal HCl solution for determination of available phosphoric acid be made an official method.) This committee does not recommend the adoption of this as an official method, but that the referee for next year give it further trial.

Adopted.

Mr. **Bartlett**. (In regard to recommendations 3, 4, and 5, of the referee on soil analysis.) The committee, after a careful consideration of the referee's paper and examination of the methods printed in Bulletin 49, recommends that the chair appoint a committee to carefully rewrite the methods of soil analysis for the next issue of the official bulletin, the committee to act in conjunction with the secretary.

Adopted. Committee to be nominated by the chair later.

The committee on recommendations withdrew at this moment. The regular order of business was resumed, and papers and communications upon adulteration of dairy products were called for. None was presented.

Papers and oral communications on fermented and distilled liquors were called for. None was presented.

Papers and oral communications on the general subject of food adulterations, and upon analysis of normal dairy products were called for. None was presented, but the following statement was made by Mr. Patrick:

Mr. **Patrick**. I have recently discovered that the official methods do not contain the Wollny method for the saponification of fats. It seems to me it should be included. It is saponification under a reflux condenser. As I think it must have been omitted by mistake, I move that it be included in our methods as a provisional method for the coming year, the recommendation to be referred to the committee on recommendations.

Seconded.

Mr. **Lindsey**. Can anyone tell us why it was omitted?

Mr. Wiley. The present method of operation was suggested and used on account of its greater rapidity and the absolute certainty of no loss of volatile acids during saponification. I think any of you who have worked with the condenser will have noticed the odor of butyric acid in the room during the operation. Any process which would stop that entirely was thought to be better. Again, saponification under pressure takes less time, and in other respects was found to be more desirable. I should have no objection, however, to allowing persons who wish to use the older method being allowed to do so as a provisional method.

Mr. Patrick. While I have no fault to find with the pressure method, I believe that where one chemist uses the pressure method half a dozen use the reflux condenser. Since I have been at this meeting I have come across two gentlemen who use the reflux condenser. I myself always used it until within the last year. I should like to hear an expression from other members.

The President. Has anyone made a specific comparison of the two methods? If not, it is a study worthy of attention at any rate.

Mr. Wiley. I think for most fats the reflux condenser is more simple, because a special flask is required for the pressure method. As Mr. Patrick says, for ordinary work perhaps the reflux condenser is more convenient, and for fats without volatile acids is perfectly safe. I do not remember now whether we ever made any comparisons at that time or not.

Adopted, for reference to the committee on recommendations.

No communications were presented upon the subject of fermented and distilled liquors.

The President. Are there any communications upon the subject of analysis of food products? It will be recalled that there is no report from the referee on analysis of sugar. Are there any papers to present upon that subject?

Mr. Wiley. I think the methods are very satisfactory and can be safely left without change. I will say here that the Treasury Department has lately gone very carefully over the methods of polarization, in connection with the tariff on sugar, and there is now in press a pamphlet giving the conclusions of the committee appointed for this purpose by the Secretary of the Treasury, consisting of myself as chairman, Mr. Braid, of the office of weights and measures of the Coast and Geodetic Survey, and Mr. Crampton of the Internal Revenue. We have gone very carefully over the methods of polarization, and while there have been a few minor changes, they are not of sufficient importance to warrant any changes at this time. The Treasury has authorized the use of the shadow instrument, to the exclusion of the old color instrument, which was unsuited to persons who are at all color-blind. Anyone who can see can distinguish a shadow from an illumination, and that is the chief advantage the shadow instrument has over the color instrument. I believe the members of the association almost universally use the shadow instrument, but those who are not color-blind and use the color instrument doubtless can secure just as accurate results in polarization. Some improvements have been made, and I would advise any of you who are purchasing instruments now to get the triple-field shadow instrument as distinguished from the old double shadow instrument.

An important thing is that any person, connected with official work in the United States, can have his apparatus for polarization standardized by the office of weights and measures of the Coast and Geodetic Survey, free of charge. I advise members of this association to correspond with that office, and as they have opportunity have all their apparatus standardized at that place.

Mr. Huston moved that the Secretary of the Treasury be requested to forward copies of his bulletin on polarization to all members of this association. Seconded.

Mr. WILEY. I think the Secretary of the Treasury will be glad to do so. If this resolution pass, I will myself ask him to grant this favor, and am quite sure he will be glad to do so.

The resolution was adopted.

The PRESIDENT. In the absence of the committee on recommendations, the next subject is the report of the referee on tanning materials. The referee is unable to be present, but the associate referee will present the report.

Mr. Yocum read the following report:

REPORT ON TANNINS.

By JOHN H. YOCUM, *Associate Referee.*

Mr. Westenfelder, the referee for this year, sent out samples of tanning extract to various members of the association. These samples were accompanied by hide powder and a circular letter outlining the method to be pursued. Unfortunately, Mr. Westenfelder found he could not attend the meeting and turned the matter over to me as assistant referee to make the report, etc. Results were returned by five operators and are of a very satisfactory nature. Owing to a misunderstanding, last year's referee did not present a report. I made request to him for the data then collected that they might be embodied in this report, but have not received them.

The method outlined in the circular letter is as follows:

(1) Weigh about 20 grams of the sample; wash into flask with hot water, add cold water nearly to mark, cool, and make up to 1,000 cc; shake thoroughly.

(2) Immediately measure out 100 cc into a weighed dish and evaporate and dry to constant weight at temperature of boiling water. Result: Total solids.

(3) Filter about 125 cc of solution through a doubled folded filter (S & S No. 590, 25 cm), returning filtrate through filter twice. Evaporate and dry as before. Result: Soluble solids.

(4) Shake 20 grams hide powder with 250 cc of water for five minutes; strain through linen. Repeat operation three times. Finally remove as much water as possible by squeezing the material in a press. Transfer the pressed hide powder to a covered dish and weigh. Weigh off a portion approximately equal to one-fourth

of the whole and dry to constant weight. To 200 cc of original solution, add the remainder of the washed hide powder, and shake for ten minutes; add 5 grams of $BaSO_4$ free from soluble salts and shake for one minute; filter immediately through a folded filter (S & S No. 590, 15 cm), returning the first 25 cc. Filtrate must be absolutely clear; if not, repeat filtration till so. Evaporate 100 cc and dry as before. The weight of residue must be corrected for the dilution caused by the water contained in the hide powder. The shaking must be done in some form of mechanical shaker. The machine used by druggists and known as the "milk shaker" is recommended. Result: Nontannins.

(5) Shake 10 grams of hide powder with 200 cc of water for five minutes; filter through linen; squeeze out thoroughly by hand; collect hide powder and repeat operation twice with the same quantity of water. Pass the last filtrate through paper until a perfectly clear liquid is obtained. Evaporate 100 cc and dry as before. Residue should not amount to more than 10 mg. The above is test for quality of the hide powder.

(6) Test a small portion of the nontannin filtrate with a few drops of a 10 per cent solution of gelatin (Nelson's). Solution must remain unaltered (not the slightest turbidity).

(7) Test for soluble hide: Use a filtered solution (original) of the tanning material instead of the gelatin solution. There must be no turbidity.

(6*a*) If the above test show the presence of tannin, repeat whole operation with 25 grams of hide powder.

(7*a*) If above test show the presence of soluble hide, repeat whole operation with a perfectly washed hide powder.

All dryings must be done at the temperature of boiling water, viz, 97° to 99° C.

Dishes should be covered during drying and cooled in desiccators.

One hundred cubic centimeters of solution should be taken in all cases for evaporating and drying.

Dry 5 grams of sample in flat-bottom dish to constant weight for moisture.

The results reported are shown in the table. The maximum difference in total solids is 1.63 per cent; in soluble solids, 1.80 per cent; in nontannins, 0.95 per cent.

Heretofore the major differences have been in the nontannins, and the concordance in this particular in these results is very encouraging.

The soluble hide in the hide powder is reported as follows:

	Gram.
Westenfelder	0.0050
Carr	.0030
Haley	.0010
Krug	.0088
Yocum	.0030

Table of results.

Operator.	Water.	Total solids.	Soluble solids.	Non-tannins.	Tannins.	Reds.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Westenfelder	57.74	42.26	41.02	16.52	24.50	1.24
Carr	59.21	40.83	39.22	16.96	22.76	1.61
Haley	58.69	41.31	40.63	16.68	23.95	.68
Krug	58.99	41.01	40.32	16.95	23.37	.69
Yocum	58.21	42.15	39.86	17.47	22.39	2.34
Mean	58.57	41.51	40.21	16.92	23.39	1.30
Maximum difference from mean	.83	.75	.99	.55	1.21	1.04

Mr. Westenfelder reports that 10 grams of hide powder gave less than 5 mg of soluble material under conditions of testing hide. He obtained 19.18 per cent non-tannins by shaking 200 cc of the extract solution with 10 grams of dry unwashed hide powder.

Mr. Carr made report of 19.18 per cent of nontannins originally, but later found upon going over his results an error in them, and reports 16.96 per cent nontannins as the correct result.

He dried the materials in vacuo at 100° C., which no doubt makes his results on solids a trifle lower than the others.

Mr. Haley obtained 15.75 per cent of nontannins with the use of 50 grams wet-pressed official hide powder (equivalent to 10½ grams dry); 15.85 per cent with 50 grams of wet-pressed Vienna hide powder (equivalent to 12 grams dry), and 16.24 per cent with 50 grams wet-pressed hide powder of his own make (equivalent to 11½ grams dry).

Mr. Krug obtained 16.24 per cent nontannins by the use of an unofficial hide powder that gave 0.0065 gram of soluble material.

I obtained 17.76 per cent nontannins from an unofficial hide powder.

These results show that, in the hands of operators accustomed to the work, the nontannins can be obtained in better accord than can the results from simple drying of viscous solutions, such as the extract itself is.

It is generally recognized that the tannin determination is not one of a single substance, but rather of a group having much the same characteristics, and that besides the chemical union of tannin and hide there also occurs an occlusion by the hide of the other soluble materials in the extract. This precludes the possibility of obtaining anything like the exact concordance that is obtained by purely chemical methods.

The nontannins, obtained by the various operators using the official and other hide powders on the official extract, show the variations possible with hide powders, answering their individual requirements, and emphasize the necessity of some standard in this respect.

The differences in the results obtained on water and total solids are due to the same general causes that occasion differing results in the drying of other organic solids, and can be regulated to a great extent by uniformity of time and temperature of drying.

Because of the oxidation and decomposition undergone by organic matter when dried in the air it is impossible to obtain final results that represent the true percentage of water, yet most chemists making tannin determinations have not the facilities for drying in hydrogen or in vacuo, and it is as yet an open question if such treatment would prevent decomposition in tanning solutions; consequently it does not seem proper to suggest changes in this direction.

By specifying the length of time, temperature, and size of dish a better agreement may be obtained next year.

The soluble solids are influenced by the temperature of the solution when filtered. Inasmuch as the temperature of the laboratory seldom varies outside the limits of 16° to 20° C., this has little influence. The filter paper causes differences, but S & S No. 590 15 cm seems to give results of a satisfactory nature.

There seems to be more cause for difference in the temperature of the solution at the time the extract is dissolved than from either of the above causes. A solution made by dissolving 20 grams of extract in 1,000 cc of water at 16° C. stood four hours, and filtered through doubled folded 15 cm S & S No. 590 paper gave 39.09 per cent of soluble solids. The same solution standing eighteen hours gave 39.24 per cent soluble solids. Evidently the reds that are first thrown down by contact with cold water are to a limited extent redissolved on standing. By dissolving the extract at 80° C. and letting stand four hours 40.05 per cent soluble solids were obtained, and by letting stand eighteen hours, 40.07 per cent. By dissolving at 25° C. and letting stand four hours 39.75 per cent soluble solids were obtained, and by letting stand eighteen hours 39.62 per cent. By filtering with kaolin the solution made at 16° C. gave 37.54 per cent, that made at 25° C. gave 37.65 per cent, and that made at 80°

gave 38.55 per cent soluble solids. The nontannins were not influenced by any of the methods of dissolving, nor were they less from the kaolin filtrates.

Though the results upon nontannins from this year's work are in fair accord, the variations due to the use of other than the official hide powder are wide. The lowest result is from Mr. Haley—15.75 per cent—and the highest my own—17.76 per cent.

The value of a standard hide powder or a means of knowing the efficiency of a given hide powder, is great. Six hide powders were tested according to the two tests given in last year's published method (Bull. 49, p. 118), the soluble-hide test and the gallo-tannin test.

Results of the year's work are given in the following tables:

TABLE I.—*Analysis of hide powders.*

Sample.	Moisture.	Fat.	Ash.	Al_2O_3 and Fe_2O_3.	CaO.	MgO.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
No. 1	13.00	....	0.50	....	....	....
No. 2	12.40	0.49	2.66	0.25	2.61	0.04
No. 3	13.00	.39	.45	.10	.19	.02
No. 4	12.30	1.07	.17	.08	.07	.01
No. 5	14.00	.94	.48	.10	.11	.01
No. 6	12.00	.65	.73	.15	.18	.02

TABLE II.—*Comparison of washing tests on various hide powders.*

Sample.	Quantity of air-dry hide.	100 cc, first washing.	100 cc, second washing.	100 cc, third washing.	100 cc, fourth washing.	Hide removed by four washings.
	Grams.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Per cent.*
No. 1	20	0.0634	0.0134	0.0093	0.0076	1.31
No. 2	20	.1719	.0375	.0165	.0105	3.42
No. 3	20	.2192	.0525	.0196	.0096	4.32
No. 4	20	.0720	.0172	.0154	.0049	1.56
No. 5	20	.2256	.0415	.0098	.0058	4.10
No. 6	20	.1172	.0254	.0110	.0073	2.37

TABLE III.—*Comparison of gallotannin test on various hide powders.*

Sample.	Weight of air-dry hide.	Weight of wet hide.	Dry hide in wet hide.	Weight of dry hide.	Dilution correction.	Weight of the nontannins.	Corrected nontannins.	Tannin absorbed.
	Grams.	*Grams.*	*Per ct.*	*Grams.*		*Grams.*	*Per ct.*	*Per ct.*
No. 1	20	27.70	44.40	12.30	1.077	0.0069	1.38	98.62
No. 2	20	33.70	27.00	9.10	1.123	.0320	6.42	93.58
No. 3	20	37.10	28.00	10.39	1.134	.0247	4.96	95.04
No. 4	20	32.20	35.00	11.27	1.105	.0120	2.41	97.59
No. 5	20	37.40	31.50	11.78	1.128	.0157	3.13	96.87
No. 6	20	47.30	22.90	10.83	1.182	.0468	9.40	90.60

In Table I is given the analysis of these hide powders, and in Table II the result of washing according to the method; in Table III the results of the gallotannin tests.

Hide No. 2 would be judged poorly prepared from its high ash, and is outside the limits designated by the method for soluble hide. Hide powders Nos. 2 and 6 are outside the limits designated by the gallotannin test.

Hide No. 1 is this year's official hide powder. I did not have enough of it to carry on the full comparison. This left Nos. 3, 4, and 5 as satisfactory hide powders. These powders were used to make comparative determinations on an extract with the following result:

Sample.	Nontannins.
	Per cent.
No. 2	18.82
No. 3	15.70
No. 4	14.72
No. 5	14.45
No. 6	18.58

Nos. 3, 4, and 5, which have satisfied the requirements, give fairly concordant results on the extract.

A further test was made by shaking for ten minutes 5 grams of air-dry hide powder with 200 cc of water, containing 5.48 grams of gallotannin.

Gallotannin per gram of hide powder.

Sample.	Gram.
No. 2, hide powder removed	0.0943
No. 3, hide powder removed	.2393
No. 4, hide powder removed	.3632
No. 5, hide powder removed	.6230
No. 6, hide powder removed	.1448

These hide powders, when completely tanned, do not show any great difference in the amount of tannin absorbed; hence it is a condition in the preparation of the hide powder that gives the more rapid absorptiveness.

These tests when applied to hide powders enable the chemist to keep a fair check on various makes of powder, and assure himself of the uniformity of a given maker's product, but more satisfactory would be the acceptance of some maker's product as a standard.

Your referee would suggest that some minor details of the method be changed and that the hide-powder tests be made to conform with the method relative to washing the hide powder. With this in view, I would recommend (Bul. 49, p. 118) the following as the coming year's method:

RECOMMENDED TANNIN METHOD.

I.—*Preparation of sample.*

Barks, woods, leaves, dry extracts, and similar tanning materials should be ground to such a degree of fineness that they can be thoroughly extracted. Fluid extracts must be heated to 50° C., well shaken, and allowed to cool to room temperature.

II.—*Quantity of material.*

In the case of barks and materials requiring extraction, use such amount of material as will give about 1 gram of solids per 100 cc of solution. In the case of extracts, weigh 20 grams, dissolve in 900 cc water at 80° C., let stand for twelve hours, and make up extract to 1,000 cc with water.

III.—*Moisture.*

Dry 3 grams of the sample, if it be an extract, in a flat-bottomed dish not less than 2½ inches in diameter to constant weight; if bark, etc., dry 10 grams.

IV.—*Total solids.*

Shake the solution, and without filtering immediately measure out 100 cc with a pipette, evaporate in a weighed dish, and dry to constant weight, at the temperature of boiling water. Dishes should be flat bottomed, and not less than 2½ inches in diameter.

V.—*Soluble solids.*

Filter about 125 cc of the solution through a double-folded filter (S. & S., No. 590, 15 cm), returning all the filtrate through once. To prevent evaporation, funnels should be inserted in small-necked flasks and covered with watch glasses during the filtration. To determine total solids, evaporate 100 cc of filtrate to dryness.

VI.—*Nontannins.*

Prepare 20 grams of hide powder by shaking for five minutes with 250 cc of water and straining through linen. Squeeze the magma thoroughly by hand, repeat this operation three times, finally remove as much water as possible by means of a press, weigh the pressed hide and take approximately one-fourth of it for moisture determination. Weigh this fourth carefully and dry to constant weight. Weigh the remaining three-fourths carefully and add them to 200 cc of the original solution; shake ten minutes, and squeeze the tanned hide through linen. Collect this filtrate, add 5 grams of kaolin free from soluble salts, stir well and filter through folded filter (S. & S. No. 590, 15 cm), returning the first 25 cc. Evaporate 100 cc of the clear filtrate. The weight of this residue must be corrected for the dilution caused by the water contained in the pressed hide powder. The shaking must be done in some form of mechanical shaker. The simple machine used by druggists, and known as the milk shake, is recommended.

VII.—*Tannins.*

The amount of these is shown by the difference between the soluble solids and the corrected nontannins.

VIII.—*Testing hide powder.*

A. Shake 10 grams of hide powder with 250 cc of water for five minutes, strain through linen, squeeze the magma thoroughly by hand; repeat this operation three times, pass the last filtrate through paper (S and S, No. 590, 15 cm) till clear, evaporate 100 cc, and dry. If this residue amount to more than 10 mg, the hide must be rejected.

B. Prepare a solution of pure gallo-tannin by dissolving 5 grams in 1,000 cc of water. Determine the total solids by evaporating 100 cc of this solution and drying to constant weight. Treat 200 cc of the solution with hide powder exactly as described in paragraph 6. The hide powder must absorb at least 95 per cent of the total solids present. The gallo-tannin used must be completely soluble in water, alcohol, acetone, and acetic ether, and should not contain more than 1 per cent of substances not removed by digesting with excess of yellow mercuric oxid on steam bath for two hours.

IX.—*Testing nontannin filtrate.*

A. For tannin.—Test a small portion of the clear nontannin filtrate with a few drops of a 1 per cent solution of Nelson's gelatin. A cloudiness indicates the presence of tannin, in which case repeat the process described under 6, using 25 instead of 20 grams of hide powder.

B. For soluble hide.—To a small portion of the clear nontannin filtrate add a few drops of the filtered tannin solution. A cloudiness indicates the presence of soluble hide, in which case repeat the process described under 6, giving the hide powder a more thorough washing.

The temperature of solutions when measured or filtered should not be below 16° C. or above 20° C. All drying should be made in flat-bottomed dishes of at least 2½ inches diameter. S and S, No. 590, 15 cm filter paper should be used on all filtrations.

Mr. Forbes, of Arizona, presented the following paper:

PREPARATION OF TANNING EXTRACTS FOR ANALYSIS.

By Robert H. Forbes.

While perfecting a method for the determination of tanning materials in canaigre, the writer was led to make some observations on the method of extraction, which are of general application.

Much of the inaccuracy of the hide-powder method, as applied to barks, woods, leaves, etc., is without doubt due to the manner of extraction laid down in the official methods. It is there advised that the ground material be digested over night at 80° with 500 cc of water. Under these circumstances a loss of tanning materials takes place, which is due to their slow recombination with the cellulose, starch (if present), and albuminoids of the material under examination.

Since the time of digestion, being "overnight," is not constant, and since the condition and amount of cellulose, starch, and albuminoids are variable, the amount of error due to their slow recombination is very irregular. In order to avoid this recombination, it is evidently necessary to devise a method by which the dissolved tannins shall be removed as promptly as possible from the extracted residue.

Extraction by percolation is a simple and nearly perfect way to accomplish this, and it is noticed on page 118 of the Proceedings of the Association for 1896 that it is recommended by the committee to extract barks, woods, leaves, etc., in a Sohxlet or similar apparatus, no details, however, as to temperature and time of extraction being given.

These considerations are of importance, inasmuch as certain materials containing difficultly soluble matters, such as hemlock bark, can not be completely extracted at lower temperatures, while canaigre, which contains starch, can not be percolated at above 50° to 55° C., because of the solution of starch with its consequent inaccuracies.

The following work was carried through with oak, hemlock, and canaigre in order: (1) To establish the fact of error due to recombination of tannings with exhausted residues when these are left in contact with the water extract. (2) To test the percolation method of extraction and note the modifications of temperature needful with different materials.

The reabsorption of tanning materials was established in the following way: A Sohxlet extractor was fitted with a 100-mesh brass wire gauze disk pushed nearly to the bottom of the tube, and a mat of woolly asbestus (previously extracted with HCl) deposited on the gauze and covered with fine asbestus.

The extractor was then placed in a sheet-metal tank of suitable dimensions and 8 to 10 inches deep, the bottom being perforated with holes which receive the rubber stoppers, through which the lower ends of the Sohxlets project. The tank was then filled with water of the desired temperature and kept at that temperature by a flame below. A weighed amount of finely ground material, 5 to 10 to 20 grams, was floated into the extractor, which was then fitted at the top with a tightly fitting rubber stopper carrying a 250 to 500 cc drop funnel. The funnel was filled with water and the rapidity of the percolation controlled by the stopcock.

The percolates (500 cc) were divided into two equal portions. One portion was examined as it stood for tannins and nontannins, while to the other, half of the extracted residue (a proportionate part) was added, the whole was digested overnight at 80° in a closed flask, the liquor cooled, filtered, and tannins and nontannins determined as before. The results were corrected for dilution by the water added in the wet residue. For comparative results, a parallel analysis was made of extracts by digesting the substance overnight at 80° according to the official method. The results were as follows:

Percentages of extracts.

Samples.	In original percolate.	In percolate redigested with extracted residne.	Difference due to absorption of tannins.	In extract obtained by official method.	Advantage of percolation over official method.
Twenty grams oak bark percolated to 500 cc in four hours at 80° C.:					
Tannins	10.99	9.98	1.01	9.68	1.31
Nontannins	5.10	5.30	....	4.78	....
Ten grams hemlock bark percolated to 500 cc in five hours at 80° C.:					
Tannins	13.74	11.80	1.94	11.12	2.62
Nontannins	3.94	4.63	....	4.13	....
Five grams of canaigre percolated to 500 cc in eight hours at 50° C.:					
Tannins	41.27	[1] 25.02	16.25	34.70	[2] 6.57
Nontannins	13.03	13.66	....	12.86	....

[1] This canaigre residue was digested with its liquor at room temperature.

[2] In this case the ground material was in contact with the liquor only two to three hours, at room temperature.

The results in columns 1 and 2 all show a reabsorption of tanning materials by the extracted residues, being greatest in the case of canaigre. The enormous loss with this material may be partly due to the presence of starch, which also reprecipitates tanning materials. The reprecipitation noted in columns 1, 2, and 3 explains the advantage of percolation over the official digestion method of extraction, as shown in columns 4 and 5.

The action of starch and cellulose, respectively, in reprecipitating the tanning materials was observed by preparing a canaigre percolate, dividing into three portions, analyzing portion 1 as obtained, redigesting portion 2 in the cold with 1 gram of shredded filter paper, and redigesting portion 3 in the cold with 1 gram of bruised starch. Portions 2 and 3 were filtered, and in both cases a loss of tannins was observed.

Percentages obtained.

Samples.	Tanning materials in original percolate.	After digestion with cellulose.	Reabsorption by cellulose.	After digestion with starch.	Reabsorption by starch.
No. 1510, old, red canaigre, percolated at 50° C.:					
Tannins	40.58	36.46	4.12	38.64	1.94
Nontannins	12.72	13.04	....	13.90	....
No. 1511, young, yellow canaigre, percolated at 50° C.:					
Tannins	31.98	28.50	3.48	30.24	1.74
Nontannins	16.12	15.26	....	16.52	....

The cellulose shows a much stronger action than starch, the reprecipitation being about twice as great.

This suggests the inaccuracies introduced into analytical work by the use of filter papers. Our repeated experiments show that the first portions of tanning extracts filtered through paper contain noticeably less solids than the latter portions—the deficiency being found due to loss of tanning materials. In order to do away with this error I now use an asbestus filter made by placing a mat of prepared woolly asbestus in a porcelain strainer funnel, covering the mat with fine asbestus, and drying the filter in an oven. By the use of this filter no loss of tanning materials occurs and the amount of total solids obtained is usually greater than in the last portions of the same liquors filtered through paper.

The effect of temperature upon completeness of extraction was shown by percolating oak, hemlock, and canaigre at different temperatures shown by the table.

Percentages obtained.

Samples.	Percolated at 55° C.	Percolated at 80° C.	Percolated at steam heat.
Oak bark:			
Tannins	9.01	10.99	10.69
Nontannins	4.44	5.10	6.75
Hemlock bark:			
Tannins	10.73	13.74	15.69
Nontannins	3.58	3.94	8.22
Canaigre, old roots:			
Tannins	41.27	....	41.74
Nontannins	13.03	....	17.84
Canaigre, young roots:			
Tannins	31.67	....	30.68
Nontannins	16.25	....	28.56

It is seen that the extraction of oak bark is complete at 80°, while hemlock, owing probably to the difficultly soluble reds, yields more extractives by continuous percolation at the higher temperature. The extraction of canaigre is complete at 50° to 55° C. It is, in fact, not possible to make a satisfactory percolation of this material above this point, since the starch then swells and clogs up the Sohxlet tube.

The percolations of canaigre at steam heat, noted in the table, were made by placing the material in a thin layer on an asbestus mat in a large continuous copper extractor. The increase in 1510 of nontannins from 13.03 per cent to 17.84 per cent, and in 1511 from 16.25 per cent to 28.56 per cent is due to the solution of starch, whose presence in the extract causes turbid filtrates and is therefore an element of inaccuracy.

The above observations show—

(1) That in the extraction of barks, woods, leaves, etc., a percolation method is essential to complete extraction, owing to the reabsorption of tanning materials by cellulose, starch, albuminoids, etc.

(2) That the percolation method must be modified to suit the material under examination. Continuous extraction at steam heat will probably manage most woody materials, but canaigre requires to be percolated at 50° to 55° C., at which point extraction is complete, and we avoid the solution of starch, which does not properly belong with soluble nontanning materials and whose presence is a source of inaccuracy in determining tannins.

(3) In accurate work the use of an asbestus filter is necessary, the loss of tanning materials in the filter thus being avoided.

(4) The following method of extraction for canaigre is recommended: A Sohxlet extractor is fitted inside with a 100-mesh brass gauze disk which is pushed nearly to the bottom of the tube, and a mat of woolly asbestus, previously extracted with hot hydrochloric acid, is deposited on the gauze. The mat is then covered with fine asbestus, the prepared extractor is placed in a sheet-metal tank of suitable size and 8 to 10 inches deep, the bottom of which is perforated with holes which receive the rubber stoppers through which the lower ends of the Sohxlets project. The tank is then filled with water at 50° C., and kept at that point by a small flame. The extractor is then partly filled with water and 5 grams of canaigre are floated into the extractor. A tightly fitting rubber stopper carrying a 250 to 500 cc funnel is then fitted to the top of the Sohxlet, the funnel is filled with water and the stopcock turned so that the percolate will run to 500 cc in four hours. The percolate is allowed to cool, made to the mark, shaken, an aliquot taken for total solids, the remainder filtered through an asbestus filter and soluble solids and tanning materials determined as usual.

(5) In conclusion, it is advisable that a more detailed examination of the percolation method, as applied to different materials, be made, and the best temperature for each one determined, as it is certain that any particular temperature can not be fixed upon for all substances alike.

Mr. KRUG. As the hour is late, I move that the report be simply given to the committee on recommendations with power to act.

Adopted, and the report so referred.

RECOMMENDATIONS.

The committee on recommendations returned to the hall and made the following additional recommendations:

We recommend the following addition to the provisional method under Dairy Products:

The Wollny method.—Use same amounts of alkali and alcohol as in previous method (pressure method) and conduct the saponification on a steam or water bath, the flask being connected with a reflux condenser not less than one meter in length and kept well cooled during the operation. Saponification will usually be completed within one-half hour.

Adopted.

Mr. Patrick moved that the referee for next year be instructed to test this method. Adopted.

Mr. BARTLETT. The committee recommends the adoption of Recommendation No. 1 of the referee on cattle foods, with the exception that the time of acid treatment be made two and a half hours instead of two hours.

The committee further recommends that the referee for next year test the following procedures—"after the starch reaction has disappeared, cool to 55° and repeat the treatment with diastase as described for thirty minutes."

Adopted, as a provisional method.

Mr. BARTLETT. The committee recommends the adoption of the phloroglucin process as a provisional method for the estimation of furfurol in agricultural products.

Adopted.

Mr. BARTLETT. The committee recommends that in the estimation of galactan the method described on page 98 of the referee's paper for 1897 be adopted as a provisional method.

Adopted.

Mr. **Bartlett**. On page 62, Bulletin 46, under "c," Official Methods, first line, that "two and a half hours" be substituted for "three hours."

Adopted.

Mr. **Bartlett**. The committee further recommends the following rearrangement of the provisional methods for cattle foods:

That the provisional methods on page 62 of the Official Methods be rewritten in the following order:

A and B, same as now printed.
C, determination of starch in commercial starches.
D, determination of starch in all other substances, diastase method.
E, determination of pentosans by the phlorogucin method.
F, determination of galactin by method described in 1897, referee's paper, page 25.
G, determination of crude fiber.

Adopted.

Mr. **Bartlett**. The committee recommends that the names referee and associate referee be substituted for reporter and associate reporter.

Adopted.

Mr. **Bartlett**. The committee recommends that the name reporter on fermented and distilled liquors be changed to referee on liquors and food adulterations.

Adopted.

Mr. **Bartlett**. The committee recommends that the executive committee, in addition to fixing the time and place of meeting, be authorized to fix the order of business and see that it is announced in the call for the meeting.

Adopted.

Mr. **Bartlett**. The committee recommends that upon the republication of the methods they be all properly named, defined, and arranged in groups in accordance therewith.

Mr. **Wheeler**. I was the originator of that. In view of the fact that in some States they provide that our official methods shall hold in court, it seemed desirable that our methods should be appropriately grouped together, the provisional as provisional, the optional as optional, and these names defined, so that all may know what is meant by provisional and optional.

Adopted.

The Chair announced as the committee on restatement of the methods of soil and ash analysis Messrs. Scovell, Peter, and Wiley.

RESOLUTIONS.

The Chair called for the report of the committee on resolutions.

Resolved, That the thanks of this association are due—

1. To the authorities of the Columbian University, and especially to President Whitman and Dean Munroe, for the use of their lecture room for our meetings, and for other courtesies.

2. To the honorable Secretary of Agriculture, for the patronage of his Department in the publication of the annual reports of the association and for the encouragement given the association by his presence and generous expressions of good will.

3. To the Cosmos Club, for its hospitality in extending to the members of the association the privileges of the club.

4. To President Frear, for the able, impartial, and uniformly courteous manner in which he has presided over the deliberations of the association.

5. To Secretary Wiley, for his efficient services and his active and continued interest in the work of the association.

J. T. ANDERSON,
W. A. WITHERS,
H. B. MCDONNELL,
Committee.

Adopted.

Mr. R. H. Atwater addressed the convention briefly on the subject of ammonium sulphate, asking the members of the association, as American citizens, to give this substance its true value.

The incoming president, Mr. Winton, read the list of referees for the coming year.

Some discussion arose as to the time of holding the meetings, some of the Southern members desiring that they be held during the summer vacation. Mr. Persons moved that the association recommend to the executive committee that the meeting be held during the summer vacation months. The motion was duly seconded, but failed of adoption.

The Chair, expressing his gratification at the amount of work accomplished and the consideration shown by the members during the meeting, declared the convention adjourned *sine die.*

OFFICERS, REFEREES, AND COMMITTEES OF THE ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS FOR THE YEAR 1898.

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A. L. **WINTON**, New Haven, Conn.

VICE-PRESIDENT.

R. C. **KEDZIE**, Agricultural College, Mich.

SECRETARY.

H. W. **WILEY**, Washington, D. C.

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M. A. **SCOVELL**, Lexington, Ky.
J. L. **HILLS**, Burlington, Vt.

REFEREES.

Phosphoric acid.—Mr. B. W. Kilgore, Agricultural College, Miss.
Nitrogen.—Mr. R. J. Davidson, Blacksburg, Va.
Potash.—Mr. C. H. Jones, Burlington, Vt.
Soils and ash.—Mr. Harry Snyder, St. Anthony Park, Minn.
Dairy products.—Mr. C. L. Penny, Newark, Del.
Foods and feeding stuffs.—Mr. W. H. Krug, Washington, D. C.
Liquor and food adulteration.—Mr. W. S. Sweetser, State College, Pa.
Sugar.—Mr. R. S. Hiltner, Lincoln, Nebr.
Tannin.—Mr. John H. Yocum, New York, N. Y.

ASSOCIATE REFEREES.

Phosphoric acid.—Mr. E. G. Runyan, Washington, D. C.
Nitrogen.—Mr. F. S. Shiver, Clemson College, S. C.
Potash.—Mr. B. B. Ross, Auburn, Ala.
Soils and ash.—Mr. B. L. Hartwell, Kingston, R. I.
Dairy products.—Mr. J. B. Weems, Ames, Iowa.
Foods and feeding stuffs.—Mr. G. L. Teller, Fayetteville, Ark.
Liquor and food adulteration.—Mr. Chas. P. Worcester, Boston, Mass.
Sugar.—Mr. Elton Fulmer, Pullman, Wash.
Tannin.—Mr. Oma Carr, Corry, Pa.

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Mr. B. H. Hite, Morgantown, W. Va.
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COMMITTEE ON FOOD STANDARDS.

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COMMITTEE ON UNIFORM LAWS FOR FERTILIZER CONTROL.

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Mr. B. W. Kilgore, Agricultural College, Miss., chairman.
Mr. C. L. Penny, Newark, Del.
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Mr. G. C. Caldwell, Ithaca, N. Y.
Mr. H. W. Wiley, Washington, D. C.

COMMITTEE ON REWRITING METHODS OF SOIL ANALYSIS.

Mr. M. A. Scovell, Lexington, Ky., chairman.
Mr. A. M. Peter, Lexington, Ky.
Mr. H. W. Wiley, Washington, D. C.

CONSTITUTION OF THE ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS.

(1) This association shall be known as the Association of Official Agricultural Chemists of the United States. The objects of the association shall be (1) to secure uniformity and accuracy in the methods, results, and modes of statements of analysis of fertilizers, soils, cattle foods, dairy products, and other materials connected with agricultural industry; (2) to afford opportunity for the discussion of matters of interest to agricultural chemists.

(2) Analytical chemists connected with the United States Department of Agriculture, or with any State or national agricultural experiment station or agricultural college, or with any State or national institution or body charged with official control of the materials named in section 1, shall alone be eligible to membership; and one such representative for each of these institutions or boards, when properly accredited, shall be entitled to enter motions or vote in the association. Only such chemists as are connected with institutions exercising official fertilizer control shall vote on questions involving methods of analyzing fertilizers. Any person eligible to membership may become a member at any meeting of the association by presenting proper credentials and signing this constitution. All members of the association who lose their right to such membership by retiring from positions indicated as requisite for membership shall be entitled to become honorary members, and to have all privileges of membership, save the right to hold office and vote. All analytical chemists and others interested in the objects of the association may attend its meetings and take part in its discussions, but shall not be entitled to enter motions or vote.

(3) The officers of the association shall consist of a president, a vice-president, and a secretary, who shall also act as treasurer; and these officers, together with two other members to be elected by the association, shall constitute the executive committee. When any officer ceases to be a member by reason of withdrawing from a department or board whose members are eligible to membership, his office shall be considered vacant, and a successor may be appointed by the executive committee, to continue in office till the annual meeting next following.

(4) There shall be appointed by the president, at the regular annual meeting, a referee and associate referee for each of the subjects to be considered by the association.

It shall be the duty of these referees to prepare and distribute samples and standard reagents to members of the association and others desiring the same; to furnish blanks for tabulating analyses, and to present at the annual meeting the results of work done, discussion thereof, and recommendations of methods to be followed.

(5) The special duties of the officers of the association shall be further defined, when necessary, by the executive committee.

(6) The annual meeting of this association shall be held at such place as shall be decided by the association, and at such time as shall be decided by the executive committee, and announced at least three months before the time of meeting.

(7) No changes shall be made in the methods of fertilizer analyses, except by unanimous consent, until an opportunity shall have been given all official chemists having charge of fertilizer work to test the proposed changes.

(8) Special meetings shall be called by the executive committee when in its judgment it shall be necessary, or on the written request of five members; and at any meeting, regular or special, seven enrolled members entitled to vote shall constitute a quorum for the transaction of business.

(9) The executive committee will confer with the official boards represented with reference to the payment of expenses connected with the meetings and publication of the proceedings of the association.

(10) All proposed alterations or amendments to this constitution shall be referred to a select committee of three at a regular meeting, and after report from such committee may be adopted by the approval of two-thirds of the members present entitled to vote.

APPENDIX.

NOTICE IN REGARD TO THE TESTING OF CHEMICAL MEASURING FLASKS, ETC.

[From Zeitschrift für angewandte Chemie, 1893, pp. 557–559. Translated for the use of the committee by E. E. Ewell.]

The Kaiserliche Normal-Aichungs-Kommission published the following directions, based upon article 18 of the regulations governing weights and measures (special supplement to Reich's Gesetzblattes, No. 30):

I. Allowable Measuring Apparatus.

1. For exclusive use for chemical volumetric analysis of aqueous solutions, glass vessels will be admitted for testing as follows:

Vessels with one mark to hold a single volume.
(*a*) Flasks.
(*b*) Pipettes with upper suction tube and a lower delivery tube.
Vessels marked to hold a certain definite volume and certain subdivisions thereof.
(*c*) Measuring glasses (also called measuring cylinders, being measuring tubes having a foot).
(*d*) Burettes (measuring tubes without a foot, but with a delivery tube).
(*e*) Measuring pipettes (measuring tubes having a suction tube at the upper end and a delivery tube at the lower end).

2. The capacity of a measuring vessel is to be limited either by the mark or the lower opening, and its quantity is marked upon the vessel for a temperature of the vessel of 15° of the centigrade thermometer, in the liter, fractions of a liter, or in cubic centimeters, in which case the cubic centimeter is to be the 1–1000 part of a liter.

3. Measuring vessels may be graduated either to hold (*Messgeräthe auf Einguss*) a given quantity to the mark, or to deliver (*Messgeräthe auf Ausguss*) a given quantity. Measuring vessels provided with a device for the delivery of liquids must always be graduated to *deliver* the volume of liquid for which they are marked. Other vessels may be graduated to either hold or to deliver, but for only one of these purposes in the case of any single vessel. The volume of liquid is measured with a delivery apparatus by filling and emptying, with precautions to retain a uniformly unpreventable moistening of the walls of the vessel. This uniform moistening is insured by observing the following precautions:

(*a*) Measuring vessels which are emptied by turning upside down are held for one minute after emptying in an inclined position to allow them to drain, when the last drop is wiped off.

(*b*) In the case of pipettes the liquid is allowed to flow out entirely, or to the lower mark, according to the method of graduation, while the delivery tube is held without motion in contact with the sides of the receiving vessel. After the free outflow of the liquid has stopped, or after the lower mark has been reached, the pipette is allowed to drain for one-quarter of a minute.

(*c*) In the case of burettes, or measuring pipettes (pipettes graduated to deliver fractions of their maximum capacity), the desired quantity is drawn out, the last drop is removed, and the reading is taken after waiting two minutes.

4. The cross section of the measuring vessel must always be circular. The space occupied by the liquid to be measured, viewed in the direction of its greatest diameter, should decrease in size above and below, best at the same rate. Where the body of the vessel has a tube or cylindrical portion sealed on, the body of the vessel must gradually merge into the cylindrical portion without any abrupt change of direction, so that there will be no hindrance to the ready outflow of the liquid.

5. The mark shall be narrow, and both it and the label shall be plainly etched, ground, or applied in some other permanent manner. It should never be merely painted. The mark should always be upon a cylindrical, regularly formed, transparent part of the vessel. Coloring the mark is permitted.

6. The mark shall pass at least halfway around the vessel and lie in the plane to which the axis of the vessel is perpendicular.

7. In the case of measuring vessels marked for subdivisions of their total capacity, these subdivisions must all be equal.

8. Capacity of a flask may be stated in liters or cubic centimeters (the mark being *liter*, *l.*, or *cc*), while all other vessels may be marked only cubic centimeters—i. e., with the mark *cc*. The mark expressing the capacity of a vessel without subdivisions is placed on the middle part of the body of the vessel.

9. The numbering of the marks on vessels marked for subdivisions of their total capacity is to be placed at the right end of the lines denoting cubic centimeters as units. These numbers must run consecutively only from either the top down or only from the bottom up.

The "cc" mark is added to the line bearing the largest number, whether it be at the beginning or at the end of the graduation.

10. There must be etched below the mark indicating the capacity, in the case of flasks and other vessels having but one graduation mark, the expression + 15° C., indicating the temperature at which the capacity of the flask is equal to the volume indicated by its label. In the cases of instruments graduated for fractions of their total capacity, this mark (+ 15° C.) is etched at least 15 mm above the graduation. There must also be placed at the left of this mark and at the same height the mark *E.* or *A.*, *Eing.* or *Ausg.*, or *Einguss* or *Ausguss*, as the case may be, to indicate whether the instrument has been graduated to hold or to deliver the volume of liquid indicated by its label.

A manufacturer's number, name, and address, and a trade-mark may be placed opposite the label mentioned above on the other side of the flask. In the case of apparatus graduated for subdivisions the manufacturer's marks are to be placed in long lines at the left of the graduation.

11. In the case of all measuring vessels the reading shall be taken at that point of the wall of the vessel where it is cut by the plane which is perpendicular to the axis of the vessel and at the same time tangent to the meniscus of the liquid at its lowest point.

12. Inflow and outflow tubes, stoppers, etc., must not end in the measuring space of the vessel or extend therein. The limiting of the measuring space directly by cocks is inadmissible. Beyond the part actually occupied by the liquid to be measured the vessel may be provided with cocks, tubes, expansions made of irregular form, etc., ad libitum.

13. In the case of measuring vessels having a delivery tube or point, the latter should be drawn out as thin as stability will permit, and its termination should be smooth and even. It is permissible to constrict the orifice somewhat. In the case of burettes of the Gay-Lussac form, the delivery point should be bent back toward the delivery tube, and should be ground obliquely on the under side.

II. MEASURING VESSELS WITHOUT MINOR GRADUATION.

(Flasks and pipettes graduated to deliver one maximum volume.)

1. Flasks may be made of the following capacities: 2, 1, ½ (0.5), ¼ (0.25), 0.2, 0.1, and 0.05 liter; pipettes, of any desired capacity from 1 to 200 cc.

2. In the case of both forms of apparatus the part bearing the graduation mark must be cylindrical (see foregoing I, 5), of uniform section, and transparent. Moreover, this cylindrical portion must pass over very gradually into the expanded part of the apparatus.

3. In the case of pipettes the suction tubes must be at least 130 mm long, and the delivery tube at least 60 mm, but not more than 300 mm, long.

4. The graduation mark must be at least 70 mm from the upper end of the neck of a flask, and in the case of a pipette at least 100 mm from the upper end and at least 30 mm from the bulb. The mark must extend entirely around the neck of the flask or the suction tube of the pipette.

5. At the point where the graduation mark is placed the internal diameter of the neck of the flask shall not be less than 6 mm, and shall not exceed the following maximum figures given for flasks of each of the sizes admitted for testing:

Capacity of flask.	Maximum internal diameter of neck.
Liters.	*Mm.*
2	25
1	20
½ (0.5)	20
¼ (0.25)	15
0.2	12
0.1	12
0.05	10

In the case of pipettes the suction and delivery tubes must have an internal diameter of not less than ½ mm and not more than 6 mm.

6. The bottom of the flask may be slightly reentrant. The circumference of the bottom of the flask must form a plane to which the neck of the flask is perpendicular. The flask must stand solidly on a horizontal surface.

7. The lower limit of the volume of a pipette may be either the end of the delivery tube or a second mark etched thereon at least 30 mm from the end.

In the case of pipettes without a cock, the delivery orifice must be of such a size that the discharge of the pipette, conformable to I, 3, (*b*), lasts:

12 to 15 seconds when the pipette is of less than 10 cc capacity.

15 to 20 seconds when the capacity of the pipette is of 10 cc or more but less than 50.

20 to 30 seconds when the capacity of the pipette is 50 cc or more but less than 100.

30 to 40 seconds when the capacity of the pipette is 100 cc or more.

In the case of pipettes provided with cocks, the testing must be made for that setting of the cock which requires the following time for emptying the pipette:

13 to 17 seconds when the capacity of the pipette is less than 10 cc.

16 to 20 seconds when the capacity of the pipette is 10 cc or more, but less than 50.

23 to 27 seconds when the capacity is 50 cc or more but less than 100.

33 to 37 seconds when the capacity of the pipette is 100 cc or more.

III. MEASURING VESSELS WITH MINOR DIVISIONS.

1. The total volume of vessels graduated for subdivisions thereof may have any value between 1 cc and 1 liter, but for cylinders and burettes shall not be less than 5 cc, and for burettes and pipettes not more than 100 cc.

2. The subdivisions permitted are as follows:

When the total capacity of the apparatus is 1 cc and up to and including 2 cc, the smallest subdivision is 0.01 to 0.02 cc.

When the total capacity of the apparatus is more than 2 and up to and including 5 cc, the smallest subdivision is 0.05 to 0.02 cc.

When the total capacity of the apparatus is more than 5 and up to and including 10 cc, the smallest subdivision is 0.05 to 0.1 cc.

When the total capacity of the apparatus is more than 10 and up to and including 50 cc, the smallest subdivision is 0.1 to 0.2 cc.

When the total capacity is more than 50 and up to and including 100 cc, the smallest subdivision is 0.2, 0.5, or 1 cc.

When the total capacity is more than 100 and up to and including 200 cc, the smallest subdivision is 1, 2, or 5 cc.

When the total capacity is more than 200 and up to and including 500 cc, the smallest subdivisision is 5 to 10 cc.

When the total capacity is more than 500 cc, the smallest subdivision is 10 cc.

3. The measuring space may be limited by lines below as well as above. In the case of pipettes, the upper graduations must be at least 100 mm from the upper end of the apparatus and at least 50 mm in other cases. The lower mark of the graduation, in cases where the bottom of the vessel is not the lower limit of the graduation, must be at least 30 mm from the lower end of the apparatus or from the beginning of the contraction of the body thereof.

4. The numbering is done as follows:

a. In case of division into 10, 1, 0.1, or 0.01 cc, every tenth mark is numbered.
b. In case of division into 2, 0.2 or 0.02 cc, every fifth line is marked.
c. In the case of division into 5, 0.5 or 0.05 cc, every second or tenth line is marked.

The numbered lines must extend entirely around the vessel. Of the other lines, the fifth in the case "a" and whenever only every tenth line is numbered, and the first line when every second line is numbered, must extend three-fifths of the way around the vessel, while all other lines extend only one-half way around.

All lines not passing entirely around the vessel must be on transparent glass; any opaque strips for facilitating the reading of the instrument must not be greater in breadth than two-fifths of the circumference of the tube.

5. The distance between two consecutive division marks must not be more than 12 mm, and for measuring cylinders graduated for each 5 cc or more, not less than 2 mm, while for all other measuring vessels this distance must not be less than 1 mm.

IV. LIMIT OF ERROR.

1. Measuring vessels without divisions.

For flasks graduated for delivery the error must not exceed the following limits:

Capacity.	Allowable error.
Liters.	*cc.*
2.0	1.0
1.0	.6
.5	.3
.2	.2
.1	.2
.05	.1

For flasks graduated to hold the quantities of liquid just named, the allowable error is one-half as great in each case.

For pipettes delivering only maximum quantity, the allowable errors are as follows:

Capacity of pipette.	Allowable error.
cc.	*cc.*
1 to 2	0.01
More than 2 to 10	.02
More than 10 to 30	.03
More than 30 to 75	.05
More than 75 to 200	.1

2. Measuring vessels with divisions—burettes and pipettes.

Maximum capacity.	Allowable error on maximum capacity.
cc.	*cc.*
1 to 2	0.01
More than 2 to 10	.02
More than 10 to 30	.03
More than 30 to 50	.05
More than 50 to 100	.1

In the case of graduated cylinders of the dimensions just given, the allowable error is double that for burettes and pipettes when the instruments are graduated to hold a certain volume, but four times as great as the errors allowed for burettes and pipettes when graduated for delivery or pouring out.

For larger measuring cylinders graduated to hold definite volumes, the allowable errors are as follows:

Maximum capacity.	Allowable error.
cc.	*cc.*
More than 100 to 200	0.5
More than 200 to 500	1
More than 500	2

When graduated for delivery or pouring, the allowable errors are just twice as great.

For measuring cylinders graduated to hold a definite volume, the maximum errors for the volumes indicated by ten of the consecutive smallest divisions must on no part of the graduation be greater than as shown below:

1 cc when the divisions equal 10 or 5 cc.
0.4 cc when the divisions equal 2 cc.
0.2 cc when the divisions equal 1 and 0.5 cc.
0.1 cc when the divisions equal 0.2 and 0.1 cc.

In the case of cylinders graduated for delivery, double these errors are allowed. In the case of burettes and pipettes graduated to 0.01 to 0.2 cc, the error must not be greater than one-third of the smallest division, and not more than one-fourth of the smallest division in other cases.

V. STAMPING.

The official stamp is etched upon flasks immediately over the graduation mark and also over the label. On pipettes graduated to deliver one maximum volume the official stamp is etched immediately over the upper mark and immediately under the lower mark, when there is one.

In the case of other measuring vessels the official stamp is placed close above the upper mark and close below the lower one; besides this, the stamp is also placed on the delivery tube, close to its end.

VI. FEES FOR TESTING.

The fees are as follows:

(*a.*) For testing and placing the official stamp on measuring vessels without divisions, 30 pf. ($0.072).

Measuring vessels having divisions, 80 pf. ($0.192).

(*b.*) For mere testing, for each complete volume or each mark tested, 10 pf. ($0.024.)

If a vessel having divisions is tested for more than 5 marks besides the one indicating the total volume, each additional mark tested is charged for at the rate given under b.

VII. PLACE OF TESTING.

The testing and stamping of measuring vessels will be done by the Normal-Aichungs-Commission until further notice.

HUBER,
Kaiserliche Normal-Aichungs-Kommission.

BERLIN, *July 26, 1893.*

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Y 3 1899

Bulletin No. 52.—(Revised.)

U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF CHEMISTRY.

EXPERIMENTS WITH SUGAR BEETS IN 1897.

BY

HARVEY W. WILEY,

Chemist of the United States Department of Agriculture.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1899.

Mich.
Y 8 1899

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Chemist of the United States Department of Agriculture.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1899.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Division of Chemistry,
Washington, D. C., January 25, 1899.

Sir: The bulletin herewith presented as No. 52 of the Division of Chemistry comprises the portion of the report which was prepared by the Chemist of the Department for the Special Report on the Beet Sugar Industry of the United States, submitted by you to the President of the United States and by him transmitted to Congress, and published as Document No. 396 of the House of Representatives at the second session of the Fifty-fifth Congress. It is deemed advisable to secure the publication of this part of the report as a bulletin of the Chemical Division in order to preserve the continuity of the reports on the sugar industry of the United States as bulletins of that division. In presenting this revised edition, advantage has been taken of the opportunity to correct some slight errors which crept into the first issue. No changes have been made in the text, nor in the illustrations accompanying it, from the document mentioned above.

H. W. Wiley,
Chief, Division of Chemistry.

Hon. James Wilson,
Secretary.

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SPECIAL REPORT ON THE BEET-SUGAR INDUSTRY IN THE UNITED STATES.

REPORT OF THE CHEMIST.

H. W. WILEY.

LETTER OF SUBMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF CHEMISTRY,
Washington, D. C., March 2, 1898.

SIR: I submit herewith for your consideration the manuscript containing the data of recent investigations on the growth of sugar beets and the manufacture of sugar therefrom.

Respectfully,

H. W. WILEY,
Chief of Division of Chemistry.

Hon. JAMES WILSON,
Secretary of Agriculture.

PREFATORY NOTE.

The investigations conducted by the Department of Agriculture for many years in the study of sugar-producing plants and methods of manufacturing sugar in the United States were suspended by order of Secretary Morton in 1893. In resuming the study of this subject by order of Secretary Wilson, it is important that citations to the work already done be presented. The student of the subject will be able from these citations to have a general idea of the scope of the work which has been accomplished, and will be guided in further research by the data contained in the brief résumé which will be appended. It is not possible in such a list of citations to refer to the work which has been done by the agricultural experiment stations nor by private individuals. A collection of the titles of all accessible works in English relating to the subject of the sugar beet has been issued by the library of this Department as the library bulletin for June, 1897, entitled References to the Literature on the Sugar Beet, Exclusive of Works in Foreign Languages.

In the résumé of citations given below are first noted the publications which have been made in the annual reports of the Department of Agriculture, and afterwards a list of the special bulletins relating to beet sugar will be found. Many important papers have been published in the annual reports, which students of the beet-sugar industry might wish to consult. It is interesting to know that as early as 1867 Dr. Antisell, at that time the Chemist of the Department, pointed out the probability that an area or belt suited to the culture of the beet might be mapped out. He gave also some of the probable data which would be used in determining the limits of this belt. The annual report for 1868 contains a reference to the fact that Henry Clay visited Europe and made a study of the beet sugar industry on the Continent, and presented the results of his studies in a speech delivered in the Congress of the United States. Careful search of the records has not been able to discover this report in print.

It is to be regretted that many of the agricultural reports are entirely out of print, and the same is true of the greater part of the bulletins which have been issued on the subject of beet sugar. It will therefore not be possible for the Superintendent of Public Documents to supply the bulletins which are marked out of print to those who may desire to secure them.

Following the résumé of the work already done is given an account of the investigations conducted under the supervision of the Chemical Division of this Department during the year 1897.

REFERENCES IN ANNUAL REPORTS OF THE DEPARTMENT OF AGRICULTURE TO MATTERS RELATING TO THE SUGAR-BEET INDUSTRY.

1862. 536. Relative to the composition of beet juice.

1867. 32. Report of Thomas Antisell, Chemist, Department of Agriculture.

Dr. Antisell indicates the following as the probable "beet belt," based on temperature conditions:

"The northern limit of the beet culture is doubtful. On the plains of Russia it is grown where the isocheimal line is 10°. If this would hold good on this continent, there is no portion of the United States too cold for its culture. This vast extent of country is naturally divided into two regions, viz: (1) The middle division of the temperate zone of the United States, lying between parallels 39 and 43, comprising Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Ohio, Indiana, Illinois, Iowa, Nebraska, southern Idaho, with an area of 453,000 square miles, is favorable to beet culture, the mean annual temperature varying between 47° and 53° F; (2) the district between parallels 36° and 39°, embracing the border States, Delaware, Maryland, Virginia, West Virginia, Kentucky, Tennessee, Missouri, with Kansas, Colorado, Utah, Nevada, and northern California, possessing an area of 675,000 square miles and a mean annual temperature of 58° to 60° F., is also favorable to the beet; so that a belt of country 7° wide in latitude and with an extent of 1,129,000 square miles is open to this industrial art."

In experiments in beet culture on the Department grounds the maximum percentage of sugar in the juice is given for each variety:

Variety.	Number of tests.	Per cent of sugar.
White Silesian:		
Red top	12	6.97
Green top	10	7.20
White Magdeburg	12	7.74
Improved White Imperial	11	7.34
Beta Imperialis:		
No. 1	12	6.70
No. 2	12	7.40
Vilmorin's Improved	12	7.40
Castlenandry Yellow	12	8.00

1867. 48. Methods of sugar manufacture in Europe.

1868. 158. Report of Theodore Gennert to the Commissioner of Agriculture. A general article on the statistics and manufacture of beet sugar.

1868. 164. Notes on the manufacture of beet sugar in Europe.

In 1867 the Department sent nine varieties of seed to Chatsworth, Ill., for trial, with the following results:

	Polarization.		Polarization.
No. 1	11.90	No. 7	11.98
2	10.95	8	13.67
3	12.59	9	13.25
4	12.21		
5	11.57	Average	12.40
6	13.52		

Mention is made in this article that while in Europe Henry Clay took much interest in the beet-sugar industry and afterwards, in a speech in Congress, predicted great results from the introduction of the industry into the United States.

1869. 334. A review of the manufacture of sugar in Europe.

1869. 345. A letter included in the above review. It reviews the manufacture in Europe and mentions trials made in the United States. The first attempt to produce beet sugar in this country, mentioned in this review, was by John Vaughn and James Ronaldson, Philadelphia. Seed was imported and beets were grown, but no factory was built.

1870. 98. Report of the Chemist on Beet Sugar. He states that the returns of the growth of sugar beets in this country have not yet shown an approach to that amount of sugar which is yielded by the growth of France and northern Germany. Beets grown at Chatsworth, Ill., from seeds supplied by the Department of Agriculture contained from 9.31 to 11.24 per cent of sugar.

1870. 215. Progress of the beet sugar industry in Europe. A brief statistical article.

1870. 210. Largely historical. Three establishments were in operation—Chatsworth, Ill., Alvarado, Cal., Sauk County, Wis. Capacity of the Chatsworth factory, 50 tons of beets per day.

1872. 154. Report of Ryland T. Brown, Chemist, United States Department of Agriculture. Following are some of the chief points mentioned:

The experiments of David L. Child, at Northampton, Mass., 1838, are probably the earliest recorded in this country.

The factory of Bonesteel and Otto, at Fond du Lac, Wis., 1867, had a capacity of 10 tons of beets per day; capital, $12,000.

Analyses of beets grown on the experimental farm of the University of Virginia, 1872, viz:

Variety.	Weight.	Sugar in the juice.
	Ounces.	*Per cent.*
White Silesian (French seed)	24¼	11.75
Carter's Prize Nursery (English seed)	16	13.72
Vilmorin's Improved (French seed)	30⅛	12.54
White sugar beet (Philadelphia)	33⅛	10.17

1872. 451. April, 1872, the legislature of New Jersey passed an act, operative for ten years, exempting beet-sugar factories from taxation.

1873. 108. A brief report by the Statistician.

The two California factories produced an estimated total of 750 tons of sugar during 1873.

1873. 287. Relative to the capacity and product of the Alvarado factory. Capacity, 7,000 tons of beets per annum.

1875. 512. A résumé of a German report on the composition of sugar beets.

1876. 153. Statistics of the production of sugar in various countries. Mention is made in this article of a factory at Soquel, Santa Cruz County, Cal. The State Agricultural Society of California reported in 1874 that the production of beet sugar in the State amounted in 1870 to 500,000 pounds; in 1871 to 800,000 pounds; in 1872 to 1,125,000 pounds, and in 1873 to 1,500,000 pounds.

1876. 266. Statistics of the yield of beet sugar, by countries.

1877. 243. A brief statement as to soils suitable for beets.

1877. 579. German statistics.

1878. 117. Analysis of a sample of beet-root sirup.

1879. 67. A report on the analysis of seven sugar beets received from various parts of the country. The percentage of sugar in the juice ranged from 8.9 to 14.3, the latter sample being from Oswego, N. Y.

1879. 184. General sugar statistics.

1880. 9. Report of the Commissioner of Agriculture. A report of the condition of the Maine Beet Sugar Company and a statement of the experiments in Delaware were made. Capacity of the Maine factory, 150 tons per day. In 1877 the State legislature of Delaware appropriated $300 as premiums to farmers for crops of sugar beets, and in 1878 $1,500 were appropriated for the same purpose. Imperfect experiments were made in 1878 by the Delaware Beet Sugar Company. The total crop amounted to 350 tons of roots, yielding an average of 9 per cent of sugar. A new factory was built by Colwell Brothers, of New York, costing $30,000, with a capacity of 60 tons of roots per day of twenty-four hours. The company did not make running expenses, but the experiment was encouraging.

1880. 619. A letter from E. H. Dyer urging a bounty law.

1881. 675. Statistics of sugar production. Statistics of domestic sugar are given in brief. Beet sugar was made successfully for three successive seasons in California in one factory. The Maine factory, which was in operation for three seasons, producing in one year 1,200,000 pounds and in another 1,000,000 pounds of sugar, was obliged to suspend operations for want of beets, which the farmers thought they could not grow at the prices offered, namely, $5 to $6 per ton.

1884. 22. Report of H. W. Wiley to the Commissioner of Agriculture on the Northern sugar industry in 1883. This is an abstract of data given in Bulletin No. 3 of the Division of Chemistry.

1884. 529. Yield of beet sugar in Russia.

1886. 341. Analyses of sugar beets grown in various parts of the country. Most of these samples contained very little sugar, with one exception. This sample contained 18.84 per cent, and was from Menominee, Mich. The highest percentage of sugar in the other samples was 11.71. Twenty-eight tests were made.

1889. 140. Cultivation of the sugar beet. Report of the Chemist.

1890. 167. Experiments with sugar beets. Abstract of a report published in full in Bulletin No. 27 of the Division of Chemistry.

1891. 150. Experiments with sugar beets. Abstract of a report published in full in Bulletin No. 30 of the Division of Chemistry.

1891. 156. Laws relating to taxation and bounties in various countries.

1892. 128. A résumé of experiments with sugar beets. Full details of this work are published in Bulletin No. 36 of the Division of Chemistry.

1892. 467. Statistics of beet-sugar production for the year 1892:

	Pounds.
Utah Beet Sugar Company	1,473,500
Alameda Sugar Company	2,506,860
Western Beet Sugar Company	11,390,921
Chino Valley Beet Sugar Company	7,903,541
Oxnard Beet Sugar Company	2,110,100
Norfolk Beet Sugar Company	1,698,400
Total	27,083,322

In 1891 these factories produced a total of 12,004,838 pounds.

1893. 175. Experiments with sugar beets. This is an abstract of a report published in full in Bulletin No. 39 of the Division of Chemistry.

1893. 184. Growth of beets at different altitudes.

LIST OF BULLETINS ISSUED BY THE DIVISION OF CHEMISTRY RELATING IN WHOLE OR IN PART TO SUGAR BEETS.

Bulletin No. 3, Division of Chemistry, Department of Agriculture. The Northern Sugar Industry; edited by H. W. Wiley, 1884; pp. 118 (out of print). Pages 24 to 29 of this report relate to the beet sugar industry.

Bulletin No. 5, Division of Chemistry, Department of Agriculture. The Sugar Industry of the United States; edited by H. W. Wiley, 1885; pp. 224 (out of print).

Part second of this report, including pp. 73 to 136, inclusive, 12 plates, relates to the beet-sugar industry.

Bulletin No. 27, Division of Chemistry, Department of Agriculture. The Sugar Industry: Culture of the Sugar Beet, and Manufacture of Beet Sugar; edited by H. W. Wiley, 1890; pp. 262 (out of print).

Bulletin No. 30, Division of Chemistry, Department of Agriculture. Experiments with Sugar Beets in 1890; edited by H. W. Wiley, 1891; pp. 93 (out of print).

Bulletin No. 33, Division of Chemistry, Department of Agriculture. Experiments with Sugar Beets in 1891; edited by H. W. Wiley, 1892; pp. 158 (out of print).

Bulletin No. 36, Division of Chemistry, Department of Agriculture. Experiments with Sugar Beets in 1892; edited by H. W. Wiley, 1893; pp. 74 (out of print).

Bulletin No. 39, Division of Chemistry, Department of Agriculture. Experiments with Sugar Beets in 1893; by Harvey W. Wiley, with the collaboration of Walter Maxwell, 1894; pp. 59.

MISCELLANEOUS BULLETINS AND REPORT.

Special Report No. 28, United States Department of Agriculture. Report on the Culture of the Sugar Beet and the Manufacture of Sugar Therefrom, in France and the United States; by Wm. McMurtrie, 1880; pp. 294 (out of print).

Farmers' Bulletin No. 3, United States Department of Agriculture. Culture of the Sugar Beet; by H. W. Wiley, 1891; pp. 24 (out of print).

Farmers' Bulletin No. 52, United States Department of Agriculture. The Sugar Beet: Culture, Seed Development, Manufacture, and Statistics; by H. W. Wiley, 1897; pp. 48.

PLAN OF THE INVESTIGATIONS FOR 1897.

On the 11th day of January, 1897, the following letter was addressed to the Secretary of Agriculture:

SIR: Numerous inquiries for sugar-beet seed have come to this division instead of to the seed division, and I am unable to give any definite answer to our correspondents in respect of the policy of the Department regarding the distribution of the seeds in question. I would be glad to know if it would be possible for the Department of Agriculture to provide a few thousand packages of high-grade beet seed which could be distributed to inquiring farmers. There is a widespread interest in this country in the sugar-beet industry, and it appears to me that a part of the money voted by Congress for the distribution of seeds could be very profitably used in supplying experimenters with the best quality of sugar-beet seed. Farmers can not be certain in buying beet seeds from dealers that they are getting anything more than the ordinary quality of garden seeds. The guaranty of the Department, however, that they are securing high-grade sugar-beet seeds would be of great advantage.

I am now engaged in a revision of Farmers' Bulletin No. 3, to be used in supplying the information which is so largely asked for respecting the culture of the sugar beet and the manufacture of sugar therefrom. It would be of interest to make a statement in this bulletin in regard to the possibility of securing the seeds from the Department. An early reply to this inquiry will be appreciated.

I am, respectfully,

H. W. WILEY, *Chief of Division.*

The honorable the SECRETARY OF AGRICULTURE.

In reply to this request, in the following letter the information was conveyed that no funds were available for the purchase of beet seeds:

UNITED STATES DEPARTMENT OF AGRICULTURE,
OFFICE OF THE ASSISTANT SECRETARY,
Washington, D. C., January 13, 1897.

DEAR SIR: The Secretary has handed me your letter of the 11th instant, calling his attention to the advisability of distributing some sugar-beet seed in connection with the present Congressional seed distribution.

If this matter had been mentioned in time it would have been possible to purchase a supply of beet seed. As it is now, however, the whole appropriation for the purchase of seed is exhausted. There is not a dollar left with which sugar-beet seed could be purchased. If you will bring the matter up early next June it will be possible to include sugar-beet seed in the distribution of the following year.

Very truly, yours,

CHAS. W. DABNEY, JR., *Assistant Secretary.*

Dr. H. W. WILEY, *Chemist.*

All further attempts to reestablish the investigations looking to the introduction of the sugar-beet industry in the United States, which had been suspended during four years, were therefore deferred to await the action of the new Administration.

Immediately after Secretary Wilson assumed the duties of his office, arrangements were made for a renewal of the investigations, but that date was entirely too late to purchase seeds directly from the growers in Europe; therefore arrangements were made with the Oxnard Beet Sugar Company, which kindly offered to donate the quantity of seed required for the purpose. As rapidly as possible the seeds were sent to different parties in the United States interested in the subject, special attention being given to distributing the seed in those localities where the theoretical conditions for the production of sugar were the best. Packages were sent directly to the addresses of parties in different parts of the country, and large quantities of seed were distributed through the media of agricultural experiment stations, boards of trade, business men's associations, and others interested particularly in the culture. It is impossible, therefore, to determine the number of persons who were actively engaged in the work during the year.

In so far as possible the cooperation of the agricultural experiment stations was secured, it being deemed advisable to conduct the experiments in each State under the direct auspices of the State authorities. It was only when such cooperation could not be secured or where preference was shown for direct communication with the Department of Agriculture, and in miscellaneous cases, that the experiments were conducted directly under the auspices of the Department. Copies of Farmers' Bulletin No. 52, containing directions for planting and cultivating the crop, were sent to every person directly interested in the experiments, as well as to many others.

The promiscuous method of investigation which has been practiced during this and preceding years is faulty and unsatisfactory. In former reports the objections to such investigations have been outlined. In Bulletin No. 27 of this division (on pages 6, 7, and 8) is found a number of statements relating to the general conduct of experimental work, which are still pertinent. Inasmuch as this bulletin is out of print, it will be found of interest to repeat these statements here:

> It must be understood that the object of this bulletin is not to give a complete treatise upon the culture of the sugar beet and the manufacture of sugar therefrom, but simply to indicate, for the information of those interested, the general principles of this industry. One especial object which will be kept in view is to prevent those intending to engage in this industry from going wrong in the beginning and squandering their money and time in battling with problems which science has already met and overcome. It is further hoped that the careful study of the data presented will prevent any mistakes from being made which would end in financial disaster and which are so apt to attend the early history of every industry.
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> There will probably be found for many years to come in the United States more enthusiasm than knowledge connected with the sugar beet, and the result of this will be, unless great care is taken, that many ventures will be made which may result in financial disaster, disaster which could have been avoided by a thorough comprehension of the fundamental principles of the industry.
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> In so far as the manufacture of sugar from the matured beet is concerned, we are able to start at the present time with the accumulated knowledge and experience of three-quarters of a century of investigation. So perfect have the processes of manufacture become that nearly all of the sugar which is stored in the beet can be secured in merchantable form and by comparatively inexpensive methods. By the term inexpensive, however, it must be understood that the actual processes of manufacture are denoted and not the cost of the machinery. The various processes for the extraction of the sugar from the beet, the best methods of clarifying the juice and of evaporating it and for separating the sugar from the molasses, are thoroughly

well understood and are no longer legitimate subjects for public experiment. The great problem in this country is the agricultural one. The selection of suitable soil, the finding of the proper climatic conditions, and instruction in the method of planting, cultivating, and harvesting the beets, are all matters of vital importance. Without a careful study of these subjects, and without the proper knowledge thereof, it is a hopeless task to attempt to introduce successfully the beet-sugar industry into this country.

One of the great dangers to be avoided is the formation of hasty conclusions in regard to the proper localities for the production of the sugar beet. Often without any study whatever of the climatic conditions or of the character of the soil, efforts are made to build large and expensive factories, which as often have to be abandoned on account of having been wrongly located. The studies which have been made heretofore in regard to climatic conditions have been of such a nature as to locate, in a general way, the areas in the United States suitable for the culture of the sugar beet.

It has been found in general that the coast valleys of California, and probably large areas in Oregon and Washington, certain parts of the Dakotas and Nebraska, localities in Minnesota, Iowa, Wisconsin, and Michigan, parts of northern Illinois, Indiana, Ohio, and New York present favorable conditions for sugar-beet culture; but in the regions thus broadly intimated there are certain restricted areas most suitable to the sugar beet, and it is only these restricted areas to which we must look for success. The fact that in one locality, for instance in Nebraska, good sugar beets can be produced would be no warrant whatever for assuming that all parts of that State were equally suitable for this purpose, and this remark may be applied to every one of the States mentioned above.

Sugar beets have also been raised in other sections in the United States, notably in New England, New Jersey, Delaware, and Kansas, and while there may be areas in the New England States where beets can be successfully grown, it must be admitted that the States last named stand in the second rank of beet-sugar producing localities. In Kansas, during the last year, as will be shown in the body of this report, sugar beets were grown and a considerable quantity of sugar manufactured therefrom. This, however, does not show that Kansas will be able to compete with more favorable States in the production of beet sugar.

In general, it may be said that the summers in Kansas are too hot to expect the production of a sugar beet uniform in its nature and containing a high percentage of sugar.

If the sugar-beet industry is to succeed in this country, the success must come from sharp competition with the same industry in older countries, where its conditions are better understood and where the localities suited to it have been selected by long and often costly experience. It must also compete with the sugar-cane industry, both of this country and of tropical countries, and for this reason we can only expect it to survive in those regions where soil and climatic conditions, proximity to fuel, cheapness of labor, and other favorable environments are found.

It is to be hoped that the mistakes which have so long threatened the sorghum-sugar industry with destruction may be avoided with the sugar beet. Calm judgment and sober reason must not give way to enthusiasm and extravagant expectations. All conditions of success must be carefully studied, all the difficulties in the way of success must be intimately investigated and surmounted, and ample capital, coupled with judicious perseverance, must be enlisted in its behalf.

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For the proper erection and completion of a beet-sugar factory not less than twelve months should be allowed, and even in this time it can only be properly accomplished under experienced technical control.

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In Bulletin No. 30 (on page 7) the following observations are found:

Only in a few instances were the directions of the Department followed out to the letter. In most cases the planting and cultivation of the beet seed were conducted according to such methods as the agriculturist might hit upon at the time. From the information gathered it was found that the chief variation from the instructions was in the preparation of the soil. In very few cases was a subsoil plow used and most of the beets which were sent to the Department were evidently grown in soil of insufficient depth. In some cases, where the exact directions for cultivation were carried out, the character of the beets received showed by contrast with the others the absolute necessity of employing the best methods of agriculture for their production.

In Bulletin No. 33 (on page 9) the following statement is made:

One of the most striking features in regard to this method of conducting experimental work is found in the fact that it is almost impossible to secure compliance with directions. It is evident, at once, that the value of experimental work depends upon the care with which it is done and the accuracy with which the directions prescribed are followed. It is not to be wondered at that farmers, busy with their other occupations, failed to comply with the minute directions necessary to secure the greatest advantage in experimental work.

Very few of the blanks were returned properly filled out. In many cases the data which were returned were palpably erroneous. In one instance a yield of 99 tons per acre was reported, and in a great many cases the reported yield per acre was so great as to show inaccuracy on the part of the measurement of the land or the weighing of the beets. In making out returns for such reported phenomenal yields the theoretical quantity of sugar per acre given was always questioned. We are accustomed to look with suspicion upon any yield of sugar beets which exceeds 25 tons per acre. While it is not impossible to secure a higher yield than this, and of beets of good saccharine quality, yet it is so rare as to throw doubt upon miscellaneous data showing an excess of that yield.

Another point, which makes the returns obtained less valuable, is found in the fact of the length of time which necessarily elapsed between the harvesting of the beets and their reception at the laboratory. Nearly all the samples received were from distant States, requiring for packages of this kind from three to eight days in the mails. Although the beets were in most cases well wrapped, according to directions, our experiments have shown that they must have lost a considerable quantity of moisture by evaporation during their long transit. The data, therefore, showing the content of sugar in the juice would be uniformly too high for normal beets. It is estimated that not less than 10 per cent should be subtracted from the number for sugar to express the normal percentage of sugar in the beets as originally harvested.

In Bulletin No. 36 (on page 28) the ideas outlined above are somewhat expanded in the following words:

Before proceeding to discuss the data in the preceding tables, attention should be called to the fact that in previous reports of this kind some dissatisfaction has been expressed in some States on account of the poor showing of the samples therefrom. In former reports attention has been particularly called to the probability that the data obtained by this method of experimentation are not wholly reliable and in all cases do not truly represent the capabilities of any locality for beet-sugar production. It is true that a large number of data received from a given State will indicate, in a general way, whether or not that State is capable of producing a good sugar beet, but where the number of data is limited, it may be that the agricultural conditions under which the samples were produced were so poor, or the season so exceptional, as to prevent a fair judgment of the capabilities of the soil and climate. On the other hand, the culture which the samples received may have been so careful and the seasonal conditions so favorable as to produce a beet far above the average which could be produced in the whole State.

Again, the loss of moisture during transportation, or the failure of the farmers to send their beets in as soon as harvested, may tend to reduce the amount of water present in the beet and to raise correspondingly the quantity of sugar therein. Inasmuch as the analyses are made on the expressed juice, this would tend to show always an increased amount of sugar over that present naturally in the beets.

All these disturbing influences must be taken into consideration in judging the data which have been recorded. This has been said in general explanation so as to forestall any criticisms which may be made of the value of the data obtained.

To illustrate more particularly what is meant, attention is called to the instance, say, of Colorado and Montana. From the State of Colorado one hundred and twenty-three samples were received for analysis, and from the State of Montana only one sample. Any comparison, therefore, between the average results of the two States would be simply absurd. While one hundred and twenty-three samples from Colorado, showing, as they do, fine possibilities of sugar-beet culture, indicate that the State of Colorado is capable of producing beets of high quality, the single sample from Montana, whether it proved exceptionally poor or exceptionally fine, could have been no criterion by which the capabilities of the State for beet sugar could be judged.

In connection with the tentative results which have been obtained by this kind of work should be considered the characteristics of the soil and climate of each locality, and by putting the two together a fairly good idea can be formed of the possibilities of beet-sugar production. The reader should carefully bear the above explanation in mind, both in looking over the data in the tables and in reading the remarks thereon which follow.

In Bulletin No. 39 (on page 8) in commenting on the results of the year's work, the following statements are made:

> The general results of the work this year are somewhat discouraging as compared with previous years. Throughout a great part of the beet-growing region the summer was excessively dry, and large numbers of total failures were reported.
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> In former reports attention has been called to the fact that the present method of experiment is unsatisfactory, and the reasons therefor have been fully set forth. The farmers are so busy with other work that, as a rule, they are not able to give careful attention to the experimental details. They do not have the time to suitably prepare the soil for beet culture, nor do they give the growing beet proper attention. When the time for harvesting comes they are usually engaged in other farm work, so that the beets are not harvested at the right time, nor are data obtained by means of which any accurate estimate of the yield per acre can be determined. The analytical data, therefore, of such work are usually fragmentary and far from teaching any definite lesson in regard to the industry itself. In general, however, the data bear out those of previous years in showing the areas in this country where the best beets can be grown. It is in these regions that the development of the industry must be expected.
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> There is probably not a State or Territory in the Union which is not capable of growing a fair article of sugar beets. Even in the far South beets of fair sugar content have been produced, and with good tonnage; but when the competition of the world is to be met, with the price of sugar as low as it is now, only those parts of the country where the soil and climate are especially favorable can be expected to compete successfully with the beet-sugar industry already firmly established in older countries. The sole valuable lesson, therefore, of the promiscuous distribution of beet seed is in the fact that, as a rule, those regions best suited to the growth of the sugar beet will gradually be outlined, and intending investors led to the proper localities for the establishment of factories.

The great success of the beet-sugar industry on the Pacific coast leads to the conclusion that if the northern part of the eastern and central portions of our country is to become the seat of a great sugar industry, every possible advantage must be taken of soil and location, in order to compete successfully with the beet fields of California, Washington, and Oregon.

The experience of the past season, as will be seen from the data in the following pages, has served only to give additional point to the observations made in previous bulletins.

The sugar-beet industry in this country has now reached a point where it is incumbent upon the National Government to secure a complete and accurate agricultural survey of the country in respect of growing beets. The competition in sugar making is now so keen that only those localities where natural conditions are best will, in the end, be found sustaining the industry. If we depend upon costly experiment to delimit these localities, hundreds of thousands of dollars will be wasted in the attempt. At a comparatively small expense, the Department of Agriculture will be able to have made careful and accurate surveys, based upon experimental data, to point out the regions where the sugar industry is most likely to succeed. This, however, can not be done by the promiscuous kind of experimentation which the Department has been compelled heretofore to pursue. Up to this time a sufficient scientific interest in the matter has not been aroused among the people to secure the kind of a survey which is necessary. Now, however, the conditions have changed. The agricultural experiment stations in most of the States are thoroughly aroused in this matter. They are willing, with the cooperation of the Department, to undertake an agricultural survey of their respective localities. In addition to this, intelligent men, either in their capacity of private citizens or as representatives of boards of trade, or of business men's associations, are ready to supervise, in limited districts, series of experiments which will give satisfactory answers to the questions which must be answered before the sugar-beet industry is fully established. It will therefore be the object of the Department in subsequent work, especially that of 1898, to secure in each locality interested in the matter, a few carefully conducted experiments. To this end it is urged that the experiment stations in the various States arrange with 25, 50, 100, or more representative farmers, who can be relied upon to do good work, to grow plats of beets in size of not less than half an acre.

CLIMATOLOGY.

It is evident that one of the first things to be considered, after the soil itself, in connection with the sugar-beet industry is the climate. The sugar beet is a plant very susceptible to climatic conditions. At the beginning of its growth the beet plant is peculiarly helpless. It can not lift, in passing from the germ to the new plant, the lightest clod. A rain which packs the surface of the soil immediately after germination will sometimes prevent the plant from reaching the light.

After the plant is established it requires a considerable quantity of water for its proper growth; this water must be supplied either by the rainfall of the locality, by irrigation, or by the subsoil. High temperatures extending over long periods of time are peculiarly injurious to the storing of sugar in the tuber. While high temperatures may not diminish the tonnage yielded by a field, nor apparently produce any injurious effects, in so far as the external appearance of the mature plant is concerned, it will be found, as a rule, that plants grown under such conditions of temperature are less rich in sugar than others grown in a milder climate. Since the production of sugar in the leaf of a plant is a joint function of the chlorophyll cells and sunlight, it is found that the high northern latitudes, where the summer days are exceptionally long and the nights correspondingly short, tend to produce, other conditions being the same, a beet rich in sugar. The climatic conditions of this country are so different from those of Europe as to render of little value the general conclusions which experience has drawn from the effect of climate, in the beet-sugar producing countries of Europe, on the sugar content of the beet itself. Nevertheless, it is seen that in Europe the great centers of the beet-sugar industry are in regions far to the north, in fact, so far north as to make it impracticable ever to expect, in this country, to establish the centers of the industry on the same parallels of latitude. When it is considered for a moment that the great capitals of Europe—St. Petersburg, London, and Berlin—are situated 1,460, 870, and 940 miles, respectively, north of Washington, and yet in prosperous agricultural communities the above statement does not create surprise. The vicissitudes of climatic conditions in northern Europe are also less marked than they are in the United States. Throughout the beet-growing area of Europe it is expected that the summers will be mild. They are not attended with many days of excessive heat. Spring comes early and permanently; the autumn comes slowly and late. In France and Belgium a severe frost is not expected in May, nor is it anticipated that ice of a considerable thickness will form in October. The summer days in these localities are considerably longer than even in the more northern portions of our country, and at least an hour longer than in the centers of our greatest agricultural prosperity. We find, therefore, so great a deviation in their climatic conditions that we can not apply with rigidity in this country the rules respecting the climate deduced from the experience of European countries. With those rules applicable in this country, it would be easily demonstrable that the great center of the sugar-beet industry on this continent would be in Canada, and not in the United States. We have, therefore, had to depend so far largely on theory in the application of the principles of climatology in the culture of the sugar beet in the United States. The experimental data which have been at our disposal have been fragmentary, and, as has already been noted, have not been secured in the systematic way desirable. The result is, even to-day, that many of our theories

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in regard to climate are not yet substantiated by facts. In the light of the data at hand, in the publication of previous reports it has been assumed that the beet-sugar zone of the United States would be found located over an area of which the southern limit would be marked by the mean isotherm of 71° F. for the summer months of June, July, and August. While this temperature is considerably higher than the mean temperature of the European beet-sugar areas for the same period of time, it has always been evident that the beet area of the United States would necessarily be situated farther south than the like area of Europe. There are two reasons which make this location imperative. In the first place, the more northern latitudes not only have late springs, but even after the spring is once established the occurrence of a heavy frost is not unusual. In the second place, these same latitudes have short autumns, and the occurrence of heavy frosts in late October or early November are not at all unexpected. As a result of this, the season for the growth and harvest of the beet is too short if we should apply for the mean summer temperature the same rules as obtain in Europe. It is evident, however, that the assumption of the mean isotherm of 71° for June, July, and August as the southern limit of the beet-sugar area is based upon so many independent conditions as to render it only useful as a working basis.

OTHER CONDITIONS.

In connection with the temperature must be considered the rainfall, the contour and the nature of the soil, the possibility of irrigation, the abundance of subsoil moisture, the proximity of coal, limestone, and water, price of labor, facilities for distribution and transportation, and many other matters which are important in a discussion of the subject. It is further evident that the tracing of a single isothermal line and the arbitrary addition thereto of a certain width of land on either side do not give even the proper theoretical thermal basis for a careful study of climatic conditions.

MAP OF THERMAL BELT.

For this reason, the present report is supplied with a new map (Plate I), which has been kindly prepared by the Weather Bureau at our request, in which the isothermal lines for June, July, and August have been traced with greater care and from data extending over a longer period of time.[1]

The result of these new studies has been to change from former maps, in some cases slightly and in some cases considerably, the position of the mean isotherm of 70° for the three summer months named. This change, as will be seen by consulting the new map, is most marked in the case of the State of New York, where in former maps the mean isotherm of 70° was traced in a line running almost directly west from Albany to Buffalo.

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[1] Data supplied, through the courtesy of Mr. Willis S. Moore, chief of the Weather Bureau, by Mr. A. J. Henry. The map was drawn by the draftsmen of the Bureau under Mr. Henry's direction.

CHANGES IN THE NEW MAP.

In the new map the influence of the Allegheny Mountains on temperature has been more carefully studied, and as a result there has been a considerable deflection of the isotherm of 70° to the south and southwest. The general trend of this isotherm from Albany is in a southwesterly direction until the Allegheny Mountains are crossed, where it turns in a westerly direction until it reaches its former location practically in the neighborhood of Cleveland, Ohio. The position of this isotherm from this point westward is so nearly the same as that of the other map as to require no particular mention. The State of New York, however, especially that portion of it lying between Albany and Buffalo, has peculiar thermal conditions, and these are shown in a special map of that State (Pl. II). A considerable area of the State with a mean summer temperature of 70° is found in the northwestern part in the neighborhood of Rochester, while between this area and the continuous isotherm of 70°, as traced upon the map, is a considerable space of territory where the mean summer temperature is considerably below 70°. This area, however, corresponds more nearly to the beet areas of northern Europe than any other portions of our country. The temperature and other climatic conditions in this area are more uniform by reason of the modifying effects of the Great Lakes on the winds which blow from the west and northwest. The experimental data which have been collected show, therefore, that this area, although in many cases the mean summer temperature is below 70°, is peculiarly suited to the production of beets of a high sugar content. The comparatively mild springs and autumns also favor the planting and harvesting of the beet, so that the conditions of this area are as favorable to the production of beets of the proper grade as those areas lying immediately contiguous to the mean isotherm of 70°.

TRIPLE ISOTHERMAL LINES.

As a single isothermal line passing across the country affords a very narrow basis for study, it has been deemed advisable in the map herewith presented to take as the nucleus of the isothermic sugar zone not merely the isotherm of 70°, but that belt of territory, varying in width, which is bounded by the isotherms of 69° upon the north and 71° upon the south. The isotherm of 70° is found between these two, usually occupying the center of the belt, or nearly so, but sometimes approaching more nearly the one or the other. If, now, we add to the outside of the belt of irregular width, thus outlined by the two isotherms mentioned, on the south a strip of country of varying width and on the north an area bounded by the limit of dangerous frosts, this area will

practically include the whole of the United States which, from theoretical conditions of temperature, is best suited to the growth of sugar beets of a high saccharine content.

BEET ZONE.

The shaded portions of the map herewith presented indicate in a general way this area. No attempt has been made to extend this lateral shading west of the Missouri River. The paucity of data for the western part of the country, in connection with the extreme vicissitudes of climate, renders of little value any extension of the thermal belt.

ANNUAL RAINFALL.

Connected with this study, the annual precipitation is of the utmost importance. There has therefore been marked upon the map, in the area covered by this belt, the mean precipitation, in inches, from 50 to 40, from 40 to 30, and so on down to the least recorded quantities of rainfall in the far western arid regions.

The mean annual precipitation is, of course, of importance in determining the relations of the different regions to the water supply and the need of irrigation. It is also important to know the mean precipitation for the months during which the chief growth of the crop and the harvest take place, namely, for April, May, June, July, August, September, and October. The mean precipitation for each of these three months, as furnished by the Weather Bureau for the localities mentioned, is indicated in the following tables:

Monthly averages of rainfall, April–October.

Stations.	Latitude.	Longitude.	Elevation.	Number of years.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Total.
MASSACHUSETTS.	° ′	° ′										
Amherst	42 22	72 32	235	61	3.1	3.9	3.7	4.5	4.4	3.4	3.9	26.9
Boston	42 21	71 04	12	79	3.8	3.7	3.2	3.6	4.3	3.4	3.8	25.8
Fall River	41 42	71 09	259	22	3.9	4.0	3.1	3.5	4.4	3.3	4.5	26.7
Fitchburg	42 36	71 50	433	32	2.9	3.8	3.3	3.7	4.3	3.2	4.1	25.3
Lowell	42 39	71 17	104	42	3.6	3.7	3.3	3.8	4.4	3.3	3.8	25.9
New Bedford	41 39	70 56	100	83	3.6	3.8	3.0	3.1	3.9	3.3	3.7	24.4
Springfield	42 05	72 35	70	47	3.2	4.2	3.8	4.5	4.5	3.4	4.2	27.8
Taunton	41 54	71 05	30	22	3.6	3.3	2.5	3.5	4.2	2.8	3.8	23.7
Worcester	42 16	71 49	473	43	3.7	4.1	3.1	3.8	4.5	3.5	4.4	27.1
CONNECTICUT.												
Hartford	41 45	72 40	38	27	3.0	3.6	3.0	4.1	4.6	3.2	3.9	25.4
New Haven	41 18	72 56	10	45	3.3	3.9	3.1	4.5	4.6	3.8	3.8	27.0
New London	41 21	72 05	8	26	3.7	3.6	3.2	4.0	4.7	3.4	4.4	27.0
Middletown	41 33	72 39	37	33	3.4	3.8	3.5	4.3	4.8	3.6	4.1	27.5
Southington	41 35	72 51	152	26	3.1	3.2	2.8	3.9	4.6	2.9	3.6	24.1
Wallingford	41 27	72 49	73	35	3.6	4.2	3.6	4.2	5.0	3.6	4.2	28.4
NEW YORK.												
Albany	42 40	73 45	32	69	2.8	3.6	4.1	4.2	4.0	3.5	3.5	25.7
Buffalo	42 53	78 53	587	27	2.5	3.4	3.5	3.2	3.2	3.3	3.6	22.7
Cooperstown	42 42	74 57	1,300	43	2.6	3.6	4.1	4.3	4.1	3.4	3.3	25.4
Gouverneur	44 25	75 35	423	21	2.1	2.7	2.7	2.8	2.3	3.1	3.4	19.1
Ithaca	42 27	76 30	375	36	2.2	3.4	3.7	3.5	3.0	3.0	2.9	21.7
New York City	40 43	73 58	52	61	3.4	4.0	3.8	4.0	4.7	3.4	3.6	26.9
North Salem	41 20	73 34	361	23	3.4	4.4	3.5	4.0	4.1	3.1	4.1	26.6

Monthly averages of rainfall, April–October—Continued.

Sections.	Latitude.	Longitude.	Elevation.	Number of years.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Total.
NEW YORK—cont'd.	° ′	° ′										
Oswego	43 29	76 35	335	26	2.1	2.8	3.4	3.1	2.6	2.8	3.3	20.1
Palermo	43 20	76 22	....	42	2.3	2.8	3.3	3.3	2.7	3.2	3.4	21.0
Rochester	43 08	77 42	494	27	2.5	3.3	3.3	3.0	3.0	2.4	2.9	20.4
Utica	43 06	75 13	473	41	2.7	3.5	4.3	4.7	3.5	3.5	3.5	25.7
NEW JERSEY.												
Atlantic City	39 22	74 25	13	23	3.3	3.1	3.0	3.5	4.3	3.2	3.2	23.6
Lambertville	40 23	74 57	75	25	3.3	4.4	3.8	4.4	4.9	4.3	3.6	28.7
Newark	40 45	74 10	13	52	3.5	4.0	3.5	4.4	5.0	3.8	3.6	27.8
New Brunswick	40 30	74 27	48	43	3.7	3.9	3.9	4.7	4.9	3.8	3.4	28.3
South Orange	40 45	74 15	141	26	3.3	3.2	3.6	4.9	5.2	4.0	3.7	27.9
Trenton	40 14	74 45	33	24	3.7	4.1	3.9	5.5	5.3	4.0	4.0	30.5
Vineland	39 29	75 01	97	25	3.3	3.9	3.3	4.3	4.9	4.0	3.4	27.1
PENNSYLVANIA.												
Blooming Grove	41 23	75 09	....	25	3.2	4.0	4.1	5.0	4.9	3.1	3.6	27.9
Dyberry	41 38	75 18	1,100	25	2.5	3.4	3.1	4.6	3.8	2.8	3.3	23.5
Erie	42 07	80 05	686	23	2.5	3.8	3.9	2.8	3.3	4.0	4.1	24.4
Gettysburg	39 49	77 15	624	24	3.5	4.0	3.5	3.4	3.6	3.0	3.1	24.1
Harrisburg	40 16	76 53	320	25	3.0	4.6	4.4	4.2	3.9	3.6	3.3	27.0
Pittsburg	40 22	79 59	745	54	3.0	3.5	3.6	4.0	3.4	2.9	2.8	23.2
Philadelphia	39 53	75 10	32	72	3.4	3.8	3.8	4.0	4.3	3.5	3.2	26.0
MARYLAND.												
Baltimore	39 17	76 37	68	26	3.4	3.8	4.0	4.7	4.0	3,9	2.9	26.7
Cumberland	39 39	78 45	639	24	2.5	3.4	3.8	3.4	3.2	2.8	2.3	21.4
Emmitsburg	39 43	77 20	498	12	3.5	4.6	3.9	3.4	3.3	3.8	3.8	26.3
Frederick	39 24	77 24	415	15	3.7	4.4	4.6	3.5	2.7	3.7	2.5	25.1
OHIO.												
Cleveland	41 30	81 42	582	41	2.7	3.5	3.9	3.4	3.1	3.6	2.8	23.0
Columbus	39 58	83 00	812	17	3.2	4.2	3.5	3.2	3.2	2.6	2.6	22.5
Marietta	39 30	81 26	611	69	3.3	3.9	4.1	4.4	3.9	3.1	3.1	25.8
North Lewisburg	40 11	83 35	1,030	25	3.1	3.9	4.0	4.4	3.3	3.2	2.2	24.1
Steubenville	40 25	80 41	663	39	3.4	3.9	4.0	4.0	3.9	3.5	3.1	25.8
Toledo	41 40	83 34	579	26	2.2	3.4	3.4	3.1	2.7	2.4	2.4	19.6
Wauseon	41 36	84 07	767	23	3.0	4.2	4.1	3.4	2.7	2.6	2.6	22.6
Westerville	40 04	82 46	850	35	3.0	3.4	3.8	3.9	3.3	3.1	2.1	22.6
INDIANA.												
Angola	41 36	85 00	1,052	11	2.9	4.5	3.7	2.7	2.7	3.8	2.3	22.6
Columbia City	41 09	85 30	863	16	3.4	4.5	4.1	3.2	2.7	3.9	1.9	23.7
Connersville	39 40	85 03	844	14	3.7	4.4	4.3	2.4	2.7	2.6	2.2	22.3
Farmland	40 11	85 10	1,040	14	3.4	4.7	4.0	2.8	3.5	3.6	2.0	24.0
Fort Wayne	41 05	85 07	815	13	3.2	3.9	3.8	4.9	3.4	3.2	3.0	25.4
Indianapolis	39 46	86 10	753	27	3.6	4.0	4.5	4.2	3.3	3.1	2.8	25.5
Lafayette	40 28	86 54	667	16	3.7	4.8	4.2	3.7	3.5	2.7	2.2	24.8
Logansport	40 45	86 22	586	19	3.5	5.0	4.2	2.9	2.9	3.1	2.5	24.1
Mauzy	39 37	85 23	......	13	3.5	4.2	4.5	2.2	2.7	3.1	2.5	22.7
Richmond	39 51	84 53	850	26	3.6	4.3	3.9	3.5	3.9	4.1	2.8	26.1
Spiceland	39 48	85 18	1,063	28	2.9	3.8	4.4	4.1	3.3	3.1	2.2	23.8
Wabash	40 48	85 49	698	10	2.9	4.2	4.6	3.4	3.0	2.5	3.6	24.2
ILLINOIS.												
Athens	39 57	89 45	800	16	4.1	4.8	5.7	3.4	3.0	3.3	2.5	26.8
Augusta	40 12	90 57	674	19	4.0	4.1	4.1	4.8	3.6	4.1	2.9	27.6
Aurora	41 47	88 08	648	22	3.2	4.0	3.8	3.3	3.4	3.2	2.9	23.8
Chicago	41 52	87 38	589	30	3.0	3.7	3.7	3.4	2.9	3.0	2.7	22.4
Elmira	41 10	89 49	505	17	3.2	4.1	4.1	3.2	3.6	3.3	2.1	23.6
Galesburg	40 56	90 22	786	12	2.9	3.5	4.0	3.7	4.2	4.1	2.6	25.0
Geneseo	41 27	90 06	845	11	2.7	3.1	3.8	2.9	3.0	3.6	2.7	21.8
Havana	40 18	90 05	475	11	3.5	3.6	4.2	4.6	2.5	3.8	2.2	24.4
Hennepin	41 16	89 21	....	13	3.0	3.7	4.1	3.0	2.8	2.6	2.7	21.9
Marengo	42 15	88 37	819	45	2.8	3.9	4.3	3.7	3.7	3.8	2.4	24.6
Mattoon	39 29	88 24	737	15	4.2	5.0	4.8	3.9	3.4	2.9	2.8	27.0
Oswego	41 40	88 22	670	16	3.0	3.9	4.0	3.1	3.0	2.8	2.8	22.6
Ottawa	41 22	88 48	688	25	2.9	4.0	3.6	3.6	2.9	2.9	2.3	22.2
Peoria	40 42	89 36	452	41	3.2	3.8	3.7	4.0	3.0	3.5	2.5	23.7
Philo	39 59	88 08	771	11	3.8	4.2	4.2	2.7	2.1	3.3	1.7	22.0
Pontiac	40 54	88 40	600	6	2.2	3.2	3.2	2.2	1.5	1.7	1.5	15.5
Rockford	42 15	89 05	730	22	3.3	4.0	4.8	3.6	3.2	2.4	3.2	24.5
Rock Island Arsenal	41 32	90 38	528	14	2.7	3.9	3.9	3.7	3.3	3.2	1.6	22.3
Sandwich	41 31	88 32	656	17	3.7	4.6	4.3	4.5	4.5	3.5	2.5	27.6

Monthly averages of rainfall, April–October—Continued.

Sections.	Latitude.	Longitude.	Elevation.	Number of years.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Total.
ILLINOIS—continued.	° ′	° ′										
Springfield	39 48	89 39	644	17	3.7	5.0	4.4	2.8	2.4	3.2	2.7	24.2
Sycamore	42 00	88 42	800	15	3.6	4.3	5.0	3.6	2.9	3.0	3.1	25.5
Watseka	40 48	87 45	640	7	3.7	5.6	3.7	3.0	2.4	2.9	2.6	23.9
Winnebago	42 17	89 12	861	18	3.2	4.0	4.1	3.5	3.2	3.6	2.3	23.9
Wyanet	41 30	89 45	750	11	3.8	4.6	4.5	4.2	4.7	4.8	2.4	29.0
WISCONSIN.												
Beloit	42 30	89 11	741	30	2.9	3.2	4.0	3.5	3.6	3.4	2.5	23.1
La Crosse	43 49	91 15	657	24	2.4	3.3	4.5	4.0	3.2	4.2	2.3	23.9
Madison	43 05	89 24	857	28	2.6	3.5	4.5	4.0	3.1	3.1	2.6	23.4
Manitowoc	44 07	87 46	593	33	2.4	2.6	3.6	3.5	3.2	3.0	2.6	20.9
Milwaukee	43 02	87 54	591	53	2.8	3.4	3.8	3.2	2.7	3.0	2.2	21.1
MICHIGAN.												
Detroit	42 20	83 03	580	46	2.6	3.1	3.8	3.6	2.6	3.0	2.6	21.3
Grand Haven	43 05	86 18	593	25	2.6	3.4	3.8	2.8	2.7	3.6	3.2	22.1
Grand Rapids	42 57	85 40	604	14	2.8	3.6	4.2	2.4	2.4	3.4	2.5	21.3
Kalamazoo	42 20	85 38	770	20	2.6	4.4	4.5	3.2	2.6	3.2	2.8	23.3
Lansing	42 44	84 32	836	33	2.4	3.4	4.0	3.1	2.7	2.9	2.5	21.0
Port Huron	43 00	82 26	584	22	2.1	3.4	3.5	2.4	2.6	2.6	2.8	19.4

STUDY OF PARTICULAR LOCALITIES.

North Carolina and West Virginia.

The elevated areas of the mountain regions of North Carolina and West Virginia afford conditions of temperature and precipitation which are favorable to the growth of sugar beets. The rough and mountainous character of this portion of the country, however, presents mechanical difficulties in cultivation of sufficient magnitude to warrant the statement that the beet industry on a large scale is not likely to be established within it. A portion of the region specified has a mean annual rainfall of more than 50 inches, while the most of it is supplied with a rainfall of 46 inches. It is not probable, on account of the consideration mentioned above, that the beet-sugar industry, on a scale of any magnitude, will ever be established in the regions specified.

Eastern Shore of Maryland.

The isotherm of 71° enters Maryland at a point about the center of the Atlantic coast of the eastern shore, and runs north by northeast almost to Poughkeepsie, N. Y. It is evident, therefore, that the temperature conditions of this region are similar to those on or south of the isotherm of 71° in other parts of the country, although here in this area the region lies to the west of this isotherm. Judged by this factor, and also by the mean annual rainfall, which is 40 inches for this locality, the cultivation of the sugar beet might be successfully inaugurated along the Atlantic coast of the eastern shore; in fact, practically over the whole of the southern portion of the eastern shore of Maryland. The character of the soil in this locality is mostly sandy, and its natural fertility has been considerably diminished by long years of cultivation. There is no reason to doubt, however, the fact that with proper fertilization and cultivation the requisite degree of fertility for the production of sugar beets could be secured. The general tendency in this region is in the direction of a too high temperature and too few hours of sunshine. The above observations apply also to Accomac County, Va.

DELAWARE.

The observations which have been made in regard to the eastern shore of Maryland also apply to the eastern region of Delaware. On account of the ravages of the "yellows" among the peach orchards of southern Delaware, it might be worth while for the agricultural experiment station to make a careful survey of the southeastern portion of the State with reference to the possibility of producing sugar beets of the requisite degree of saccharine strength. The surface of the soil is generally level; a good deal of it is of a sandy nature, and so far as its physical properties are concerned, it may be regarded as favorable to beet growth.

NEW JERSEY.

The mean isotherm of 71° degrees passes northward almost parallel to the Atlantic coast of New Jersey, and at varying distances therefrom. The part of New Jersey lying between this isotherm and the seacoast is mostly composed of sandy soils, reasonably level. There are no mechanical difficulties of any magnitude connected with the culture of the beet, and the problem of fertilization of the soil is one which is easily solved. The same observations in regard to possibilities of beet culture may be made of this region of New Jersey as have been made in respect of Maryland and Delaware. This general observation relating to the whole may be added:

We have in this area a mean summer temperature of 71°. In no place does it reach the isotherm of 70°. The whole region may therefore be regarded as representing that of a maximum temperature compatible with beet culture. It may be further said that the culture of the beet should only be pushed south and beyond the isotherm of 71°, where peculiar natural advantages, independent of thermal factors, are afforded. These natural advantages consist of exceptionally fertile soil, favorable contour of the surface, cheapness of fuel, facilities for transportation, etc. A large portion of the region which has been mentioned is devoted to truck farming for the markets of large cities, and it is doubtful if this remunerative form of agriculture could be replaced successfully with sugar-beet culture in competition with more northern localities, where richer beets can be produced. Nevertheless, the possible production of fairly good beets in the region indicated must be admitted from the point of view of temperature and precipitation alone.

CONNECTICUT.

It will be observed that, both in respect of precipitation and temperature, the whole of Connecticut may be regarded as lying in the beet belt. From theoretical considerations, therefore, it could be predicted that beets grown in Connecticut would show a satisfactory content of sugar and possess a high purity. So favorable are the theoretical conditions in that locality that it would be advisable for the agricultural experiment stations of the State to make a systematic agricultural survey of the possibilities of growing beets. The valley of the Connecticut River affords a fertile field of experiment where the mechanical conditions of culture and the natural conditions of the soil are factors which favor success. There are large areas of the State, however, so broken in contour as to render the possibilities of beet culture unpromising, but wherever large bodies of fairly level land with good fertility can be found it is fair to presume that the culture of the sugar beet would be attended with success. Conditions which obtain in Connecticut are also found in the State of Rhode Island, although a portion of that State lies north of the isotherm of 69°. As will be seen farther along, however, in discussing the conditions of growth in New York, there are many localities in the United States north of the isotherm of 69° where beets flourish; in fact, it may be said that the possibilities of growing beets north of the isotherm of 69°, where reasonably mild autumns can be expected, are much better than south of the isotherm of 71°.

MASSACHUSETTS.

The valley of the Connecticut, in the State of Massachusetts, doubtless affords as fine facilities for beet culture as in the State of Connecticut. The greater part of the State lies north of the isotherm of 69°. As in the case of Connecticut, there are doubtless many regions in this State north of the isotherm of 69° where, owing to the mild autumns, the sugar beet may be expected to grow satisfactorily for sugar-making purposes. A large part of the State is unfitted, by reason of its contour and the nature of the soil, for the culture of beets, but at least the Connecticut Valley and similar stretches of soil might be used to good advantage for this purpose.

NEW HAMPSHIRE AND VERMONT.

These States, lying north of the isotherm of 69°, will have to contend in the growth of beets with the shorter growing season and less heat for the three months of June, July, and August for forcing the beets to maturity. Nevertheless, it is doubtless true that for a distance of 100 miles, or even more, north of the isotherm of 69° beet culture could be practiced with success on account of the longer summer days. Samples of beets received from Vermont and analyzed in this laboratory show favorable contents of sugar, and high purities. Those grown also at the experiment station of Vermont, as will be seen farther on, afford encouraging data. The thing to be feared in these localities is not inability to grow a beet rich in sugar, but the possibility of being able to harvest and secure it properly before the advent of winter. These areas do not enjoy the immunity from sudden changes of temperature, due to the lake breezes, which is characteristic of the great plain of the State of New York between Albany and Buffalo.

NEW YORK.

In this State we have a remarkable variety of thermal conditions. The mean isotherms of 69° and 70° pass in a southwesterly direction from Albany into the State of Pennsylvania, following, in general, the trend of the ranges of the Allegheny Mountains. The influence of these high altitudes is seen in forcing these isotherms to the south. The southeastern portion of the State of New York lies, therefore, within the belt of isotherms peculiarly favorable to beet culture, with the exception of the valley of the Hudson from a point a few miles above Poughkeepsie to the mouth of the river. This valley, including the city of New York, has a higher temperature than that deemed most suitable to beet culture. As this valley is, however, unfitted by reason of its contour to the culture of beets, the above fact is of little importance. Passing to the west of Albany, the mean summer temperatures for the three months of June, July, and August are considerably below the standards which have been mentioned until the region immediately east of Rochester is reached, where again we find a mean isotherm of 70°, and about Palmyra of almost 71°. Southwest of this the mean temperatures of the summer are again below 69°. Nevertheless, a fairly satisfactory agricultural survey of this region has shown that it is capable of producing beets of high quality; and the effects of the lake breezes upon the climate have doubtless much to do with this condition. For instance, in regions in this area where the mean summer temperature is below 69° the autumns are far more mild than in the similar regions in Minnesota, so that the months of October and November can both be relied upon with great certainty for securing the harvest of the beets. As has been before mentioned, we have in this region a nearer approach to the conditions of beet growing in northern Europe than in any other place in the United States. This whole region, therefore, must be considered and included in the area of our country where the theoretical conditions, and where the actual conditions, of temperature and precipitation favor the production of a beet of high saccharine content. If we should leave out of the calculation the southern deflection of the isotherms of 69° and 70°, due to the Appalachian system, and connect directly the area, in the neighborhood of Rochester, where these temperatures obtain, with Albany, neglecting the intermediate temperatures, we should have the isotherms occupying practically the same position in this new map that they were made to occupy in the former maps furnished by the Signal Office for this Department. In the absence of definite information on the subject, it is fair to presume that the former maps were made in this way, and this accounts for the discrepancy in the position of the isotherm of 70° found in these maps and in the one now presented. Abundant experimental data go to show that the total area of the State of New York south of Saratoga is well suited to the growth of beets, wherever the physical conditions of contour are favorable and the soil suitable. The map of the beet area has therefore been extended so as to include this region in the beet belt.

PENNSYLVANIA.

A large portion of the State of Pennsylvania, from the thermal point of view alone, is well suited to the growth of beets. The position occupied by the belt of territory included between the isotherms of 69° and 71°, however, in the State of Pennsylvania indicates an area which, for physical reasons, is mostly unsuited to beet culture, as it covers principally the mountainous region of that State. The northwestern part of the State, especially the portion bordering on Lake Erie, has the same favorable conditions for beet culture as are found in the great valley of the State of New York; and the principal development of the industry in that State, for the physical reasons mentioned above, must be looked for in that section. South of the isotherm of 71° there may be favorable regions in the southern and eastern portions of the State, but the altitude has pushed the isotherms too far south to look for the best results in the southwestern part of the State, on account of the shorter days due to the more southern latitude. Where conditions of contour and fertility of soil are favorable, the whole portion of Pennsylvania north and west of the isotherm of 71° may be regarded as favorable to beet culture. The precipitation immediately west of the Allegheny Mountains is not so great as on the east, but there is an area in the extreme northwestern part of the State where the mean average precipitation is nearly the same as that east of the mountains, namely, between 40 and 50 inches.

OHIO.

The northeastern and northern parts of Ohio are well situated for beet culture. In general, the contour of the land is favorable, being reasonably level, and the soil is fairly fertile. The conditions in these localities are fairly comparable with those in the State of New York, except that the mean temperature is higher, the mean isotherm of 70° running in a northwesterly direction across the northern part of Ohio and entering the lake near Sandusky. It is probable also that to a considerable distance south of the isotherm of 71°, good beets can be grown, but where so large an area is found with more favoring climatic conditions, it is not well to push the industry too far south until more favorable localities are fully exploited.

MICHIGAN.

A large part of the southern peninsula of Michigan is directly in the heart of the beet belt. The contour of the soil is also favorable, being reasonably level, with an average fertility, and the data which have been secured in actual experiments in those regions are of the most encouraging kind. There seems to be no doubt of the fact that this locality is among the best in the United States for beet culture, and the modifying influence of the lake on the autumnal climate must not be lost sight of.

INDIANA.

The northern counties of Indiana, especially the northwestern, are situated in the beet area, and it is probable that the culture of the beet may be extended southward, as in the case of Ohio, as far as Fort Wayne and Lafayette, although it is not advisable for intending investors to locate in the more southern areas until the more northern have been fully exploited. The agricultural survey of the northern part of the State, undertaken by the experiment station at Lafayette, in conjunction with the work of this Department, will indicate finally with more accuracy than a mere theoretical map the most favorable conditions of culture. Great interest has been manifested in Indiana in the extreme southwestern portion, near Evansville, in the culture of the beet, and, as will be seen in the following data, many samples have been secured from that portion of the State. In many respects this region is most favorable to beet culture, particularly on account of the facilities for transportation, cheapness of fuel, and the fertility of the soil. The mean summer temperature, however, is so high as to cause grave doubts concerning the future success of beet growth in that locality.

The soil in northern Indiana is much like that of Michigan—sandy, reasonably level, and fairly fertile—and there is reason to believe that an industry profitable both to the farmer and manufacturer may grow up in that part of the country.

ILLINOIS.

The northern part of Illinois is in the beet-sugar belt, and the conditions in respect of contour of the surface and fertility of the soil, facilities and cheapness of transportation, etc., are excellent for the sugar-beet industry. The character of the soil in northern Illinois, however, is quite different from that of northern Indiana and the southern peninsula of Michigan. It is mostly a prairie soil, dark and underlaid with clay, so that the physical conditions of culture are probably not so favorable as in the other sections just named.

WISCONSIN.

Southern Wisconsin occupies a most favorable position for beet culture, and the data which have been obtained from that State by the agricultural experiment station at Madison, in conjunction with the work of this Department, are favorable, and show great possibilities of success for the industry in that region. We begin to notice here the effects of the southwestern breezes in forcing northward the isotherms of 70° and 69°, and these hot breezes cut off from the culture of the beet large areas where soil and other conditions are extremely favorable. The same remark should be applied to the belt of country immediately south of the isotherm of 71° that has heretofore been made, namely, that there are doubtless many sections where the successful culture of the beet may be secured. This is dependent upon local conditions which must be determined by careful agricultural surveys in the future.

MINNESOTA.

The deflection in a northwesterly direction of the isotherms of 70° and 69° includes in the sugar-beet area a large portion of the State of Minnesota, especially the southeastern portion. Here there is no question of the growth of the crop and the production of beets of high saccharine qualities. The great point to be feared in this locality is the early approach of winter, and this is true of all the cis-montane western regions. We find here a drop in the rainfall from an annual average of 30 to 40 inches to one of from 20 to 30 inches. We therefore meet here a greater possibility of suffering from a dry season than in the regions of the East. As a rule, however, the quantity of rainfall during the growing season is sufficient for the production of a good crop.

IOWA.

A remarkable deflection of the isotherms of 69° and 70° is noticed in passing from Minnesota to Iowa. Not only are these isotherms deflected toward the south, but they actually take a backward course toward the east, so that their direction for a considerable distance is east of south. This brings the theoretical beet belt, so far as temperature is concerned, almost through the center of the State of Iowa. The well-known fertility of the soil of this State, with the generally level character of the surface, shows that the agricultural possibilities for the growth of sugar beets are great. In the greater part of the State the rainfall reaches 30 inches per annum, but in the northwestern part the approach to the arid region is shown by a dropping off of the average rainfall, so that it is between 20 and 30 inches. Nevertheless, experience shows that, as a rule, a sufficient rainfall is provided in all parts of the State for the growth of ordinary agricultural crops. The isotherms of 69° and 70°, after passing partly across the State of Iowa, take a sudden turn toward the north and west and pass out of the State again into Minnesota, where they reach a more northern latitude than Minneapolis. With the exception of the southwestern counties of Iowa it is fair to presume that almost the whole of the area of the State, in so far as thermal conditions and rainfall are concerned, is suited to the growth of beets. Of course, in this matter, it should be remembered, that local conditions of soil, transportation, fuel supply, and other factors must be taken into consideration. Iowa also occupies a position where there is no tempering influence of the northwestern winds, so that it begins to feel the rigors of the winter at an earlier date than is experienced on the same isotherms east of the Great Lakes.

North and South Dakota.

The conditions which prevail in North and South Dakota are somewhat unique. From the highest position attained in Minnesota, at the border line between that State and North and South Dakota, the isotherm of 69° turns again east and south and suffers a considerable deflection, due doubtless to the lower altitude of the Red River Valley. Passing, however, into Dakota the isotherms are rapidly pushed northward by reason of the hot southwest winds which are so often experienced in the summer time in those localities. For these reasons the isotherm of 69° reaches almost as far north as Bismarck, and the isotherm of 70° is only a few miles south of it. From this point the isotherms of 69° and 70° run almost due south from North Dakota entirely across the State of South Dakota and into Nebraska. The most favorable beet-sugar belt, in so far as the temperature alone is concerned, would be the area bounded by the isotherms of 71 and 69 degrees, occupying a belt of considerable breadth running north and south through South Dakota into North Dakota, and southeast through North Dakota back into South Dakota. The depression due to the Missouri River causes an area of higher temperature to extend in a northwesterly direction into South Dakota. This area, although perhaps not so favorable to beet growth as the other, is still situated in a fertile country, and doubtless has many advantages for growing beets not possessed by the higher lands to the east and west of it. There is no question of the ability of both the regions within the area specified to grow beets of fine saccharine strength. Abundant experimental data have been secured from both the States to substantiate this statement. Caution, however, must again be given in regard to the sudden advent of the winters, especially in North Dakota, where sometimes in October, and usually in November, temperatures approaching zero or even below zero, degrees Fahrenheit, are observed. These sudden falls of temperature would prove disastrous to the beet harvests, and hence tend to restrict to a certain degree the spread of the industry in that country. Again, attention should be called to the fact that the whole of the areas in the two Dakotas, where the thermal conditions are best suited to beet culture, has an average annual rainfall of only from 15 to 20 inches. The danger of drought and the possible shortage or loss of the crop from that source are therefore increased, and we begin to approach an area where artificial irrigation must be looked to in many seasons. Probably, however, in the majority of seasons the rainfall in this vicinity would be sufficient to secure a good crop.

NEBRASKA.

A study of the position of the isotherms shows that the best part of the State of Nebraska, both as respects soil and rainfall, has an average temperature of more than 71° during the summer months. The most favorable conditions of temperature are found almost in the center of the State over an area of somewhat irregular shape, and occupying a position where the extreme distance separating the isotherms of 71° and 69° is the greatest of any in the country. In Nebraska the two isotherms of 69° and 70° run almost parallel, but the isotherm of 71° runs first in a southeasterly direction, then almost south, and finally almost due west, forming a stomach-shaped area occupying a portion of Dakota and the central portion of Nebraska. The agricultural and analytical data which have been obtained in Nebraska are very extensive, and it will be observed that both of the sugar factories which have been established in that State are south of the limit of 71°. It has been observed also, by those who have had access to the analytical data of these two factories, that the saccharine contents of the beets which have been delivered to them have not been equal to those of beets grown in more favorable localities in the United States. On the other hand, the insufficiency of the rainfall in the central and western portions of the State renders less certain the growth of sugar beets, and tends to crowd the sugar factories and the sugar industry into the wetter and more fertile portions, in spite of the fact that the temperature is higher.

THE ARID REGIONS.

It will now be necessary to trace the theoretical sugar-beet belt, so far as thermal conditions are concerned, by States through the arid regions. There is so little of the area embraced in this belt which is subject to irrigation, that it is understood at once that the possible beet-sugar industry of that region must be confined to the most favorable localities. It is interesting to see, however, how the elevation produced by the Rocky Mountain range deflects the isotherms which have been traced in a generally westerly direction up to this point so far to the south. Passing from Nebraska, the isotherm of 70° runs in a southwesterly direction to a point southwest of Denver, whence it turns in a southeasterly direction to New Mexico, thence almost due south to near the Mexican border. Being deflected to the west, it ascends on the other side of the Rocky Mountain range in a general northerly and westerly direction, passing in a northwesterly direction through Utah, thence turning west and south in Nevada, being deflected again to the south by the Sierra Nevada range of mountains, which it crosses, passing from Nevada into California, whence it passes northward again along the western slope of the Sierra Nevada Mountains until it comes near the coast line in the northern part of California. Thence the isotherm of 70° is deflected southward, almost parallel with the coast line, until it passes into lower California. It is seen that all the coast valleys of California are included in the thermal belt most favorable to beet culture. The greater part of the area included in the thermal belt which has just been traced across the arid region is totally unsuited, on account of the mountainous and rough region of the surface, for agricultural uses. It is therefore evident that it is only in isolated places, where the surface of the land is smooth and irrigation can be practiced, that beet culture can be established. In connection with the thermal belt, the map shows that the mean average rainfall in many cases does not exceed 5 inches per annum.

In addition to the continuous belt thus marked out, there are some areas of varying temperature which demand attention, as, for instance, the elliptical area bounded by the isotherm of 70° in Idaho, of which Boise City is the center, and another area bounded by the isotherm of 70°, within which an isotherm of 71° is found, in the State of Washington. There is also one locality in Montana, on the Yellowstone River, where the average summer temperature is 71°.

In so far as thermal conditions are concerned, vast areas of the arid regions could be devoted to beet culture if the other conditions of culture were favorable. The differences of elevation of the plateaus cause numerous sudden changes of temperature, so that there are doubtless many localities not marked on the map where the mean summer temperature is almost identical with that which has been already mapped out. By reason of the meagerness of data, experimental and otherwise, relating to this whole region west of the Missouri River, the shading showing the probable extension of the beet area beyond the borders of the basic thermal belt has been omitted. The general discussion of this thermal belt, accompanied as it is by the chart of precipitation, is not necessary at this point. In general, in connection with this study, the remarks which are made in Bulletin No. 27, on page 169, and repeated in Farmers' Bulletin No. 52, may be recalled with profit:

> The mistake must not be made of supposing that all the region included within the boundaries of this zone is suitable for beet culture. Rivers, hills, and mountains occupy a large portion of it, and much of the rest would be excluded for various reasons. In the western portion, perhaps all but a small part of it would be excluded by mountains and drought. Beginning at a point midway between the one hundredth and one hundredth and first meridian, as indicated by the dotted line, beets could be grown only in exceptional places without irrigation. On the Pacific coast only that portion of the zone lying near the ocean will be found suitable for beet culture.
>
> On the other hand, there are many localities lying outside the indicated belt, both north and south, where doubtless the sugar beet will be found to thrive. The map, therefore, must be taken to indicate only in a general way those localities at or near which we should expect success to attend the growth of sugar beets in the most favorable conditions other than temperature alone.

The present map (Plate 1) gives in greater detail than ever before the boundaries of this thermal belt, by reason of the fact that the observations of the Weather Bureau have been more numerous, and have been compiled in a more systematic manner. It would be idle to assert that subsequent observations of the Weather Bureau may not change in a marked degree the boundaries of the belt which has been mapped. It is also quite true that the agricultural surveys which will be conducted by the several States will locate definitely, beyond the limits already outlined, the areas where successful beet culture will be practiced. I may venture the prediction, however, that these areas will be contiguous to the zone which is already mapped out, and that the future beet-sugar industry of the United States, when it shall have reached a magnitude sufficient to supply to our people a large part of the sugar they consume, will be located almost entirely within the areas which have thus been traced.

DATA FROM DIFFERENT STATES.

Two methods of collecting the data from States have been pursued. In the first place, those receiving seeds directly from the Department of Agriculture were supplied with Farmers' Bulletin No. 52, giving instructions for preparing the soil, and planting and cultivating the beets. Each person was also supplied with a series of blanks for the purpose of obtaining cultural and climatic data, and for securing as great accuracy as possible in the reports which were made. The data blanks used are represented in the following forms:

UNITED STATES DEPARTMENT OF AGRICULTURE,
Washington, D. C., August 15, 1897.

DIRECTIONS FOR TAKING SAMPLES OF SUGAR BEETS FOR ANALYSIS.

Prepared by H. W. WILEY, Chief of Division of Chemistry.

When the beets appear to be mature (September 15 to November 15, according to latitude and time of planting) and before any second growth can take place, select an average row or rows, and gather every plant along a distance which should vary as follows, according to the width between rows:

From rows 16 inches apart, length 75 feet.	From rows 22 inches apart, length $54\frac{4}{7}$ feet.
From rows 13 inches apart, length 66 feet.	From rows 24 inches apart, length 50 feet.
From rows 20 inches apart, length 59 feet.	From rows 28 inches apart, length $42\frac{9}{10}$ feet.

The beets growing in the row, of the length above mentioned, are counted. The tops are removed, leaving about an inch of the stems, the beets carefully washed free of all dirt and wiped with a towel. Where the row is not long enough to meet the conditions, take enough from the adjacent row or rows to make up the required length. Rows of average excellence must be selected; avoid the best or poorest. Throw the beets promiscuously in a pile and divide the pile into two parts. This subdivision, of one-half each time, is continued until there are about ten beets in a pile. From these ten select two of medium size. Be careful not to select the largest or smallest.

From all of the rest of the beets, save these two, the necks are removed with a sharp knife at the point indicated by the dotted line in the figure (fig. 1). The beets, including the two saved as a sample, are then weighed.

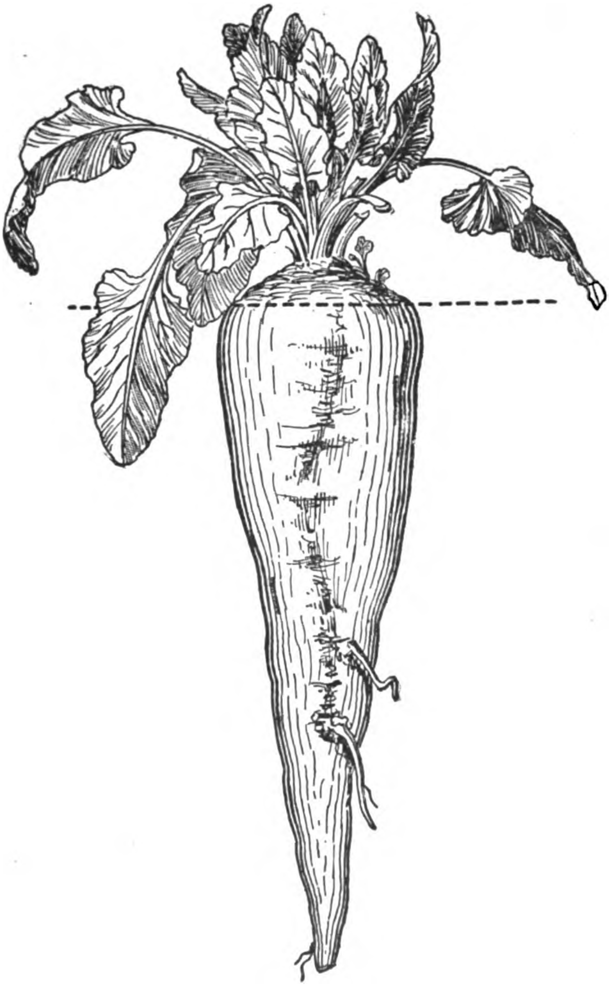

FIG. 1.—Indicating point at which top of beet should be cut off.

The number of beets harvested multiplied by 435.6 will give the total number per acre. The total weight of beets harvested multiplied by 435.6 will give the yield per acre.

Wrap the two sample beets carefully in soft paper, and write your name legibly thereon. The beets must be perfectly dry. Fill out the blank describing the beets, inclose it in the envelope, and sew it up in the bag with the beets. Attach the inclosed shipping tag to the bag and send the package by mail.

No beets will be analyzed which are not sampled as described above and properly identified.

Miscellaneous analyses of samples without accurate description are of no value.

Blanks are sent to each one for two sets of samples. From two to four weeks should elapse between the times of sending the two sets of samples.

If additional analyses be desired, other blanks will be sent on application, but not more than four analyses can be made for any one person, except in special cases.

A model, showing how blanks should be filled out, is inclosed.

[Model B.]

U. S. DEPARTMENT OF AGRICULTURE.

MODEL FOR DESCRIBING SAMPLE OF SUGAR BEETS.

Prepared by H. W. WILEY, Chief of Division of Chemistry.

Variety: Kleinwanzlebener.
Date planted: May 3, 1897.
Date thinned: June 3, 1897.
Date harvested: November 5, 1897.

Character of soil: Black prairie loam; in cultivation for 20 years, chiefly in corn; level, tile-drained; last crop, oats; no fertilizer was used; barnyard manure applied in 1895.

Character of cultivation (dates, implements, etc.): Plowed November, 1896, 8 inches deep, subsoiled 6 inches; harrowed with disk harrow May 1, 1897; rolled; seed planted with hand drill one-half inch deep; plants up May 16; stand excellent; hoed by hand May 22; plowed with horse hoe May 28 and June 8, 16, 24, July 3, 10, and 17.

Length of row harvested (feet): 66.

Width between rows (inches): 18.

Number of beets harvested: 88.

Total weight of beets, less necks and tops (pounds): 88.

Weather for each month: May, dry; June, copious rains; July, fine growing weather; August, hot and dry; September, dry until the 24th, when a heavy rain fell.

State: Iowa.

Post-office: Hanover, Buena Vista County.

Date: November 17, 1897.

Name: Robert Simpson.

NOTE.—Beets will not be analyzed unless accompanied with description as above.

It is evident that in promiscuous experimentation of this kind, even when directions are closely followed, and when all the operations are conducted in accordance with the directions in Farmers' Bulletin No. 52, and the procedure described in the blanks for taking samples faithfully followed, the data are still of an unsatisfactory nature. For instance, when a plot of beets has been harvested and quartered until the two beets required for a sample have been selected in accordance with directions, we still have an uncertainty prevailing as to whether the two beets correctly represent the whole lot. In fact, it is well known that the variations in the character of beets grown side by side are very great, far more so than is the case with sugar canes. As an illustration of this, the following analyses, giving the weight and sugar content of every beet grown in a row at the experiment station of Kentucky, is sufficient evidence:

Analyses of all the beets in a row, Kentucky station.

Serial No.	Weight after topping.	Sucrose in beets.	Serial No.	Weight after topping.	Sucrose in beets.	Serial No.	Weight after topping.	Sucrose in beets.
	Ounces.	*Per cent.*		*Ounces.*	*Per cent.*		*Ounces.*	*Per cent.*
1985	27	7.7	2009	8	8.2	2033	10	8.1
1986	25	9.9	2010	4	9.3	2034	10	7.2
1987	24	10.4	2011	1	9.9	2035	12½	9.1
1988	24	10.6	2012	1	10.5	2036	11	9.0
1989	20	8.6	2013	2	9.6	2037	11	9.8
1990	20	7.9	2014	3½	10.9	2038	9	8.8
1991	28	6.7	2015	3½	9.9	2039	9	7.4
1992	31	9.0	2016	34	8.2	2040	8	9.7
1993	18	10.4	2017	27	7.0	2041	11	8.9
1994	24	9.0	2018	20	9.3	2042	8	9.3
1995	53	4.8	2019	8	11.9	2043	9	6.9
1996	19	8.2	2020	16	6.2	2044	8	10.4
1997	33	2.6	2021	22	8.0	2045	7	9.4
1998	16	9.9	2022	15	6.8	2046	5	8.2
1999	2	10.7	2023	20	9.8	2047	4	8.4
2000	2	8.8	2024	26	9.0	2048	5	8.6
2001	2	9.6	2025	16	9.4	2049	4	8.7
2002	13	8.9	2026	18	9.7	2050	4	10.5
2003	8	9.6	2027	18	6.6	2051	4	9.3
2004	12	11.0	2028	15	8.6	2052	3	10.7
2005	6	10.5	2029	11	9.3	2053	2	12.2
2006	3	11.1	2030	17	4.9	2054	1½	10.6
2007	5	10.6	2031	12	6.8	2055	1	9.9
2008	1¾	10.2	2032	12	6.9	2056	1½	11.2

The great variations which exist, both in size and quality of beets, are most strikingly shown by the above figures. The variation in size extends from 1 to 53 ounces, and in sugar content from 2.6 to 12.2 per cent. When, however, it is considered that all overgrown and undergrown beets are rejected in taking the samples, and only those of medium size and perfect form selected, it is evident that the chances of the sample representing fairly the average of the whole lot are very much improved. Even granting this, however, it is unsatisfactory to depend upon the analysis of two or three samples alone for determining the character of the whole plot. It is evident, however, that on account of the nature of the method of investigation and the undesirability of burdening the mails with too many samples, it is impracticable to do better than has been done in this matter. The analyses of all of the samples which were sent to the Department of Agriculture from each of the States and Territories are given in the tables which are found farther along. For convenience of reference, the analyses are tabulated by counties in each case.

The second method of collecting data was through the cooperation of the agricultural experiment stations. To facilitate this, the Secretary of Agriculture appointed the directors of these stations special correspondents of the Department for distributing the seed and collecting the beets for analysis. The analyses were made by the chemists of the several stations, and they are given below, grouped under the various States. Where the cooperation of the agricultural experiment stations was secured, the reports are given by the director or officer in charge. Inasmuch as the details of these analyses are published by the various stations, including the names and residences of the persons who grew the beets, in the present report only the averages of the analyses by counties or sections, together with such observations as have seemed desirable, are given. The reports of the directors and other officers in charge contain much interesting material, and in some cases are given without abbreviation.

DATA OBTAINED IN THE LABORATORY OF THE DEPARTMENT OF AGRICULTURE.

The analytical data obtained during the season of 1897 in the Department of Agriculture have been classified as follows:

The data obtained from each State or Territory collected by counties or sections and the general average for each county are as follows:

The analytical tables showing the data of the Department samples contain the names of the States and counties arranged alphabetically. The name of each county is followed by a symbol in the shape of a square to designate the position of the county in the State. The plain square shows that the county is situated in the central portion, while a straight line attached to the center of the top of the square shows the county is in the northern part of the State; attached in a diagonal direction to the upper right-hand corner, that it is in the northeastern portion of the State; attached to the center of the right side, shows it is in the eastern portion of the State; attached to the lower right-hand corner, that it is in the southeastern portion; attached to the center of the lower side of the square, that it is in the southern part; to the lower left-hand corner, in the southwestern; to the center of the left-hand side of the square, in the western part, and to the upper left-hand corner, in the northwestern.

The tables also state the number of samples received from each county, the average weight of the samples in ounces, the average per cent of sugar in the beet, the average purity coefficient of the juice, and the maxima and minima percentages of sugar in the juice and the coefficients of purity.

In many cases the quantity of juice was too small to compute the purity in the usual way, and in others the low percentage of sugar rendered the ascertainment of the purity unnecessary. These two reasons account for the omission in many instances of the number expressing the purity of the juice.

CAUTIONS REGARDING THE VALUE OF THE DATA.

It is highly important that the persons using the analytical data contained in the following tables be cautioned in regard to the value which should be attached thereto. It is evident, in the first place, that samples which have been grown in such a promiscuous way as those received by the Department, in so many different characters of soil, under so many different climatic conditions, and with such variable culture, water supply, and fertilizing materials, must lack that uniformity of value which should characterize scientific data in general. Attention has already been called, moreover, to the fact that the few samples of beets which have been sent can not be regarded as exactly representing the whole mass of which they originally formed a part. The variations in individuals are so great under practically identical conditions as to render somewhat doubtful data which are based upon a few samples alone. For instance, in the comparison of different States in respect of sugar-producing qualities, it may be that one State is represented by perhaps less than 50 samples, while others may have 500 or 1,000. In such cases the average of the 50 samples does not in any way present such convincing data as the average of 1,000. The greater the number of samples examined, the more nearly will the disturbing influences of individuals be eliminated. When it comes to a comparison of the counties in the several States, the same remarks are true. In many instances a county may be represented by a single sample. It may be that the sample is extremely good or extremely poor. In neither case is it representative. It would be unjust, therefore, to compare a county with one sample with another from which 50, 100, or 200 samples have been received. Even in the averages representing the samples from a single county or locality care must be taken not to be misled. The samples may include, for instance, a very small beet with an excessive sugar content, or a very large one with a deficient sugar content. In case only two or three samples constitute the whole number, the influence of these abnormal samples is raised to a maximum. As an illustration of this, the analysis of samples from Clinton County, Ill., may be cited as a type of many others. Three samples were received from this county, the average weight of which was 13 ounces, and the average sugar content 15.7 per cent. One of these samples, however, weighed only 4 ounces, and had the abnormal sugar content of 21.2 per cent. It is evident, therefore, that the average percentage of sugar in the three samples is very much higher than it would have been had they all been normal in size.

Another point must not be forgotten, and that is, granting that the samples of any locality are representative, they represent only one season. That season may have been peculiarly favorable or unfavorable, and hence no section should be judged by the results of a single year's experiment. The reader who wishes to study critically the data which follow must take all these facts into consideration, and the judgment which he may form in regard to any particular section must be subject to the rectifications indicated by the variable factors mentioned above.

Table showing mean analyses and maxima and minima of the beets examined in the chemical laboratory of the United States Department of Agriculture during 1897, arranged alphabetically by States and counties.

State.	County.	Number of samples.	Averages.			Maxima.			Minima.		
			Weight.	Sugar in the beet.	Purity coefficient	Weight.	Sugar in the beet.	Purity coefficient	Weight.	Sugar in the beet.	Purity coefficient
			Ounces.	*Per cent.*		*Ounces.*	*Per cent.*		*Ounces.*	*Per cent.*	
Arizona	Apache ☐	1	26	9.6	70.4	....	....	....	....	....	....
	Pima ☐	6	23	9.3	....	30	12.0	....	9	7.6	....
Averages, etc.		7	23	9.3	....	30	12.0	....	9	7.6	....
Arkansas	Phillips ☐	1	19	10.6	....	....	....	....	....	....	....
	Poinsett ☐	1	17	11.9	71.5	....	....	....	....	....	....
Averages, etc.		2	18	11.3	....	19	11.9	....	17	10.6	....
California	Mendocino ☐	1	26	16.8	....	....	....	....	....	....	....
Colorado	Bent ☐	2	19	17.1	....	20	19.4	....	18	14.7	....
	Boulder ☐	9	31	15.3	80.9	62	20.0	86.4	15	12.5	77.0
	Chaffee ☐	2	22	15.5	....	28	17.4	....	16	13.6	....
	Conejos ☐	12	29	13.9	77.9	49	17.0	85.9	12	10.5	70.6
	Costilla ☐	4	20	13.2	82.3	28	16.3	86.9	12	9.3	84.6
	Delta ☐	2	20	17.1	80.5	23	18.6	84.3	16	15.5	76.7
	Douglas ☐	5	23	15.1	76.8	34	18.7	85.5	12	9.6	69.4
	Eagle ☐	1	14	14.5	81.7	....	....	....	....	....	....
	Elbert ☐	13	18	14.7	77.6	45	18.7	87.7	8	9.7	68.9
	El Paso ☐	3	22	13.9	76.6	39	14.7	80.1	6	12.7	73.1
	Fremont ☐	4	19	14.8	80.7	33	17.0	84.8	11	12.4	75.6
	Garfield ☐	16	14	16.6	83.2	28	20.9	85.9	9	14.4	79.4
	Huerfano ☐	1	14	17.8	....	....	....	....	....	....	....
	Larimer ☐	9	21	13.3	77.8	28	16.7	84.5	14	8.8	68.9
	Logan ☐	23	15	9.6	73.8	43	16.5	83.3	4	4.1	63.4
	Mesa ☐	4	29	15.1	81.9	49	17.6	88.1	18	11.9	75.6
	Morgan ☐	34	16	12.0	75.5	32	16.1	82.8	6	8.1	68.0
	Otero ☐	6	28	13.7	79.0	35	17.3	84.3	16	10.7	75.2
	Phillips ☐	4	33	12.0	71.4	60	14.7	75.4	18	9.7	68.9
	Prowers ☐	5	20	14.8	77.5	34	17.1	83.9	10	12.0	72.8
	Pueblo ☐	1	16	20.2	85.9	....	....	....	....	....	....
	Rio Grande ☐	5	20	15.1	80.0	33	17.6	84.1	7	12.4	76.5
	Routt ☐	2	10	18.8	....	11	19.0	....	10	18.6	....
	Saguache ☐	3	23	12.1	....	34	16.5	....	10	8.0	....
	Washington ☐	2	15	14.3	80.2	19	14.8	82.0	11	13.8	78.4
	Weld ☐	2	34	14.8	86.5	40	16.2	87.0	27	13.4	85.9
Averages, etc.		174	20	13.6	76.7	62	20.9	88.1	4	4.1	63.4

Table showing mean analyses and maxima and minima of the beets examined in the chemical laboratory of the United States Department of Agriculture during 1897, arranged alphabetically by States and counties—Continued.

State.	County.	Number of samples.	Averages.			Maxima.			Minima.		
			Weight.	Sugar in the beet.	Purity coefficient	Weight.	Sugar in the beet.	Purity coefficient	Weight.	Sugar in the beet.	Purity coefficient
			Ounces.	*Per cent.*		*Ounces.*	*Per cent.*		*Ounces.*	*Per cent.*	
Idaho	Bingham	5	18	16.2	80.5	26	18.2	86.7	6	13.9	73.2
	Fremont	2	27	14.0	77.1	32	16.1	80.1	21	11.9	74.1
Averages, etc		7	21	15.5	79.4	32	18.2	86.7	6	11.9	73.2
Illinois	Bureau	1	15	11.6	78.1	...	...	...	...	...	...
	Clark	1	18	13.8	86.8	...	...	...	...	...	...
	Clinton	3	13	15.7	73.7	21	21.2	74.1	4	12.8	73.2
	Cook	6	12	12.7	76.8	17	18.7	78.4	6	10.0	75.2
	Cumberland	2	24	14.3	77.8	32	15.2	84.7	16	13.4	70.9
	Edwards	1	8	12.7	69.0	...	...	...	...	...	...
	Effingham	2	8	11.1	...	8	11.8	...	7	10.3	...
	Franklin	1	20	11.2	67.8	...	...	...	...	...	...
	Henry	3	18	13.6	76.2	19	14.5	80.8	16	12.6	73.7
	Jackson	1	13	14.0	76.6	...	...	...	...	...	...
	Jefferson	1	9	10.2	...	...	...	...	...	...	...
	McHenry	1	57	11.9	73.0	...	...	...	...	...	...
	Macoupin	1	12	16.1	72.2	...	...	...	...	...	...
	Mason	1	30	12.6	81.0	...	...	...	...	...	...
	Peoria	1	22	14.7	77.0	...	...	...	...	...	...
	Rock Island	1	30	10.6	76.1	...	...	...	...	...	...
	Saint Clair	2	12	16.4	...	13	16.6	...	10	16.2	...
	Sangamon	2	14	12.4	69.9	16	12.8	72.0	11	11.9	67.7
	Union	1	26	8.3	...	...	...	...	...	...	...
Averages, etc		32	17	13.1	75.5	57	21.2	86.8	4	8.3	67.7
Indiana	Allen	3	28	13.4	77.7	37	15.0	78.7	17	11.9	76.4
	Delaware	1	20	14.3	77.3	...	...	...	...	...	...
	Elkhart	4	15	14.8	77.6	16	16.0	82.1	13	13.6	72.6
	Hendricks	1	14	13.9	82.9	...	...	...	...	...	...
	Henry	8	17	13.1	78.5	25	15.9	81.6	5	9.4	73.1
	Knox	1	28	10.0	71.4	...	...	...	...	...	...
	Madison	8	16	14.4	82.4	17	17.1	85.6	14	12.1	79.1
	Marion	1	9	15.1	81.9	...	...	...	...	...	...
	Morgan	3	14	14.8	80.3	17	14.9	81.5	9	14.3	78.8
	Pulaski	6	16	13.5	73.2	20	14.9	78.4	10	11.9	74.6
	Rush	1	21	12.9	80.0	...	...	...	...	...	...
	Starke	10	12.8	15.7	81.8	17	18.4	88.4	9	11.4	71.3
	Tippecanoe	17	7	15.1	81.1	20	19.1	84.4	3	12.3	78.2

	Union □	2	15	14.7	79.8	16	15.3	82.9	14	14.0	76.6
	Vanderburg □	40	14	11.2	77.3	42	13.8	87.7	7	7.8	71.4
	Warrick □	1	14	8.2	......	......	......	......	......	......	......
	Whitley □	1	16	14.0	83.1	......	......	......	......	......	......
Averages, etc	......	103	14	13.1	78.9	42	19.1	88.4	8	7.8	71.3
Iowa	Adair □	1	19	12.6	74.2	......	......	......	......	......	......
	Adams □	3	19	12.9	75.4	24	13.4	78.8	17	12.2	68.8
	Allamakee □	1	20	14.7	76.6	......	......	......	......	......	......
	Appanoose □	1	7	19.0	......	......	......	......	......	......	......
	Benton □	6	16	13.8	76.9	18	18.2	77.7	13	9.5	73.4
	Bremer □	2	15	13.6	81.3	15	15.7	83.3	14	11.6	79.2
	Butler □	1	48	10.7	72.7	......	......	......	......	......	......
	Calhoun □	2	10	18.1	......	12	18.1	......	10	16.1	......
	Carroll □	1	20	14.0	80.8	......	......	......	......	......	......
	Cass □	3	17	11.4	71.7	20	12.3	75.0	16	13.8	67.7
	Cerro Gordo □	1	32	12.7	77.8	......	......	......	......	......	......
	Clinton □	5	11	16.8	75.8	12	18.2	77.7	9	15.4	73.2
	Crawford □	2	20	8.5	......	24	11.0	......	15	6.1	......
	Dallas □	8	18	13.9	76.4	26	14.8	79.1	14	13.3	75.1
	Davis □	2	15	16.1	72.4	20	16.4	74.1	10	15.8	70.8
	Decatur □	1	16	15.6	79.2	......	......	......	......	......	......
	Dickinson □	1	15	10.9	69.7	......	......	......	......	......	......
	Dubuque □	1	17	10.0	08.3	......	......	......	......	......	......
	Franklin □	1	14	14.3	78.5	......	......	......	......	......	......
	Greene □	39	21	12.7	76.3	32	16.7	87.4	10	9.8	66.7
	Guthrie □	6	23	12.5	78.8	30	15.0	84.0	17	10.0	74.5
	Howard □	1	24	15.3	78.8	......	......	......	......	......	......
	Humboldt □	1	8	18.0	......	......	......	......	......	......	......
	Jefferson □	1	14	11.8	76.5	......	......	......	......	......	......
	Keokuk □	3	12	13.2	......	15	14.3	......	7	12.5	......
	Kossuth □	2	32	10.7	72.7	34	11.1	73.9	30	10.3	71.5
	Linn □	1	10	11.8	67.7	......	......	......	......	......	......
	Louisa □	2	19	12.8	70.3	20	13.3	71.7	18	12.2	68.8
	Monona □	1	13	13.8	78.8	......	......	......	......	......	......
	Muscatine □	2	18	14.3	80.8	18	14.3	81.0	17	14.2	80.6
	O'Brien □	15	16	13.8	76.1	32	16.4	83.0	9	9.6	69.1
	Polk □	1	10	11.3	......	......	......	......	......	......	......
	Story □	5	13	14.7	76.6	20	17.3	82.6	11	12.8	72.4
	Tama □	3	20	11.9	78.0	24	13.5	80.6	15	10.7	74.9
	Van Buren □	3	19	13.0	74.5	21	15.0	83.2	17	10.5	65.9
	Washington □	3	18	13.7	78.8	26	15.0	84.8	14	12.5	71.3
	Wayne □	1	10	14.0	......	......	......	......	......	......	......
	Winneshiek □	2	18	13.4	78.3	22	13.6	79.9	14	13.1	76.6
Averages, etc	......	130	18	13.3	73.7	48	19.0	87.4	7	6.1	65.9
Kansas	Allen □	2	28	11.1	71.5	35	11.5	71.8	20	10.6	71.2
	Anderson □	2	88	10.9	74.5	110	10.9	76.0	65	10.8	72.9
	Barton □	26	24	11.0	72.4	57	13.3	78.3	10	7.2	65.7
	Clay □	1	37	9.7	68.9	......	......	......	......	......	......

Table showing mean analyses and maxima and minima of the beets examined in the chemical laboratory of the United States Department of Agriculture during 1897, arranged alphabetically by States and counties—Continued.

State.	County.	Number of samples.	Averages.			Maxima.			Minima.		
			Weight.	Sugar in the beet.	Purity coefficient	Weight.	Sugar in the beet.	Purity coefficient	Weight.	Sugar in the beet.	Purity coefficient
			Ounces.	*Per cent.*		*Ounces.*	*Per cent.*		*Ounces.*	*Per cent.*	
Kansas	Cloud □	1	15	14.8	82.4						
	Douglas □	2	26	12.7	80.4	28	13.3	80.8	23	12.1	79.9
	Lane □	2	11	16.2	84.5	11	17.8	85.3	10	14.6	83.6
	Montgomery □	2	15	11.2		21	15.7		8	6.6	
	Morris □	1	34	11.5	70.4						
	Sedgwick □	1	22	13.8	70.8						
	Woodson □	1	35	10.8	73.5						
	Wyandotte □	1	48	9.4							
Averages, etc		41	27	11.4	73.8	110	17.8	85.3	8	6.6	65.7
Kentucky	Daviess □	1	9	15.7	83.3						
	Fayette □	4	19	11.2	68.5	21	13.3	72.5	17	9.5	65.0
	Henry □	1	10	11.1							
Averages, etc		6	16	11.9	71.5	21	15.7	83.3	9	9.5	65.0
Maryland	Anne Arundel □	4	22	7.7	73.8	26	10.5	80.3	19	3.2	67.2
	Baltimore □	3	21	9.8		38	11.1		8	8.9	
	Frederick □	2	20	13.5	82.9	24	13.7	83.2	15	13.2	82.7
	Harford □	4	13	13.8	78.9	16	15.7	82.7	7	11.6	76.6
	Montgomery □	4	23	11.9	85.0	35	14.6	85.4	18	8.6	84.5
	Prince George □	3	16	12.9	81.9	26	13.6	85.7	11	12.6	79.7
	Talbot □	3	15	11.2	78.9	19	12.9	81.8	10	9.3	75.9
	Washington □	5	18	11.8	78.5	25	15.6	77.1	12	8.0	66.8
	Wicomico □	1	32	9.0							
Averages, etc		29	19	11.4	79.1	38	15.7	85.7	7	3.2	66.8
Michigan	Allegan □	3	62	6.8		82	9.9		50	4.1	
	Alpena □	2	18	13.7	81.2	24	14.4	85.4	12	13.0	77.0
	Arenac □	1	26	8.9							
	Barry □	1	19	15.2	83.7						
	Bay □	5	24	14.2	80.5	40	16.2	83.7	16	13.2	74.6
	Calhoun □	8	17	15.8	83.2	32	16.9	89.8	12	15.1	79.8
	Delta □	2	17	16.4		24	20.2		10	12.5	
	Dickinson □	2	18	14.1	81.4	18	14.1	81.4	17	12.7	75.6
	Genesee □	1	28	14.6	81.4						
	Huron □	3	19	15.3	81.9	24	16.2	82.9	16	14.2	81.0
	Isabella □	5	24	13.3	82.2	26	16.4	86.8	20	8.2	85.7

	Kalamazoo □	2	24	16.7	78.9	29	19.0	85.7	18	14.8	72.2
	Kalkaska □	1	35	16.5	82.9	....	....	....	....	....	....
	Macomb □	3	13	16.8	80.8	14	18.6	83.2	10	18.8	78.8
	Manistee □	1	14	15.5	87.1	....	....	....	....	....	....
	Montmorency □	1	22	15.5	84.0	....	....	....	....	....	....
	Oakland □	1	16	17.4	82.7	....	....	....	....	....	....
	Ottawa □	1	9	17.0	86.0	....	....	....	....	....	....
	St. Joseph □	1	22	11.6	77.2	....	....	....	....	....	....
	Saginaw □	399	22	14.8	83.8	87	19.6	91.0	9	9.8	67.9
	Sanilac □	5	25	14.6	81.9	36	16.6	84.8	16	10.4	78.5
	Schoolcraft □	1	28	12.3	73.8	....	....	....	....	....	....
Averages, etc		450	22	14.7	81.1	82	20.2	91.0	9	4.1	67.9
Minnesota	Aitkin □	3	31	11.5	79.7	51	15.4	81.7	10	6.9	77.6
	Carlton □	1	14	15.0	84.8	....	....	....	....	....	....
	Dakota □	8	26	12.2	75.2	28	18.2	77.8	25	11.1	71.5
	Dodge □	1	24	13.0	77.0	....	....	....	....	....	....
	Freeborn □	12	20	14.1	82.3	28	15.6	86.3	15	12.3	75.0
	Goodhue □	8	23	11.7	76.1	36	18.8	88.5	16	7.7	72.7
	Hennepin □	1	43	13.3	79.4	....	....	....	....	....	....
	Mower □	1	19	13.2	75.8	....	....	....	....	....	....
	Nicollet □	2	31	11.3	72.3	32	10.9	77.1	29	10.9	67.5
	Ottertail □	4	23	14.9	82.1	30	16.0	82.8	14	18.5	82.0
	Polk □	1	8	17.7	....	....	....	....	....	....	....
	Redwood □	1	30	12.0	75.9	....	....	....	....	....	....
	Rice □	1	18	13.7	82.7	....	....	....	....	....	....
	Scott □	1	14	10.9	73.5	....	....	....	....	....	....
	Stearns □	9	29	12.7	79.8	48	15.9	83.4	20	10.4	72.6
Averages, etc		49	24	11.0	79.2	51	17.7	86.3	8	6.9	67.5
Missouri	Adair □	4	25	12.5	74.5	38	13.9	77.6	14	9.9	70.3
	Atchison □	5	53	10.6	73.3	59	12.0	75.2	84	6.3	72.2
	Audrain □	3	34	6.1	....	47	10.2	....	21	8.2	....
	Barry □	7	15	15.3	76.4	28	18.6	82.0	8	11.0	68.2
	Barton □	8	27	15.3	77.3	84	16.5	77.9	22	13.5	76.4
	Bates □	1	12	10.5	62.5	....	....	....	....	....	....
	Benton □	5	16	15.5	77.1	33	18.8	78.8	10	13.0	74.9
	Boone □	2	11	11.1	....	12	12.6	....	10	9.5	....
	Bollinger □	1	14	15.6	67.8	....	....	....	....	....	....
	Buchanan □	2	30	11.0	....	48	13.7	....	16	8.2	....
	Caldwell □	7	25	11.2	72.5	41	12.6	76.7	12	9.5	70.0
	Callaway □	5	19	9.9	77.0	29	14.6	78.5	10	4.1	74.0
	Camden □	2	14	13.8	76.5	14	13.9	77.8	13	13.7	75.2
	Cape Girardeau □	2	8	12.4	....	9	18.1	....	7	6.6	....
	Carroll □	6	27	11.8	77.6	43	14.8	84.5	4	8.1	70.1
	Cass □	4	19	11.9	66.2	24	13.5	77.5	16	9.6	58.7
	Cedar □	4	17	10.6	....	30	13.9	....	6	7.2	....
	Chariton □	5	17	11.7	75.8	28	16.2	79.1	10	8.3	72.4
	Christian □	2	12	13.3	78.9	15	13.5	83.0	8	13.1	74.9
	Clay □	1	29	8.8	....	....	....	....	....	....	....

Table showing mean analyses and maxima and minima of the beets examined in the chemical laboratory of the United States Department of Agriculture during 1897, arranged alphabetically by States and counties—Continued.

State.	County.	Number of samples.	Averages.			Maxima.			Minima.		
			Weight.	Sugar in the beet.	Purity coefficient	Weight.	Sugar in the beet.	Purity coefficient	Weight.	Sugar in the beet.	Purity coefficient
			Ounces.	*Per cent.*		*Ounces.*	*Per cent.*		*Ounces.*	*Per cent.*	
Missouri	Clinton □	1	24	8.8	....	....	....	....	....	....	....
	Cooper □	21	16	10.0	72.1	39	12.8	77.0	2	7.0	68.6
	Crawford □	2	9	11.3	....	10	11.9	....	8	10.7	....
	Dade □	2	14	13.1	....	17	13.6	....	11	12.6	....
	Dallas □	2	10	11.9	....	10	12.3	....	10	11.4	....
	Daviess □	2	21	14.8	78.0	26	15.9	82.3	15	13.6	73.7
	Dekalb □	4	31	10.6	69.6	45	11.6	72.5	12	9.9	65.6
	Douglas □	3	8	15.3	79.4	10	17.1	83.2	4	13.2	77.1
	Franklin □	6	23	12.8	72.5	37	17.2	83.2	12	9.8	68.7
	Gasconade □	10	23	11.0	72.4	31	15.5	78.5	16	7.0	65.9
	Gentry □	5	28	12.3	73.2	64	14.7	79.0	13	10.4	69.1
	Greeley □	1	12	3.6	....	....	....	....	....	....	....
	Greene □	8	17	11.3	73.2	28	16.7	83.7	8	7.6	57.8
	Grundy □	3	23	11.0	72.3	28	11.8	73.0	17	10.2	71.3
	Harrison □	4	12	14.5	77.9	17	16.4	84.2	5	12.3	74.2
	Henry □	8	18	11.9	71.5	37	17.9	74.1	3	8.9	69.3
	Hickory □	1	20	11.4	70.9	....	....	....	....	....	....
	Holt □	8	31	12.3	79.1	54	14.3	83.7	17	8.7	74.0
	Howard □	3	16	11.8	....	26	14.9	....	5	6.7	....
	Howell □	5	24	11.2	78.9	35	15.3	82.0	16	5.7	75.8
	Iron □	1	3	14.8	....	....	....	....	....	....	....
	Jackson □	1	38	10.7	70.2	....	....	....	....	....	....
	Jasper □	3	33	12.1	....	38	14.8	....	28	10.7	....
	Jefferson □	6	16	12.3	75 0	24	14.4	79.9	10	10.9	72.6
	Knox □	1	36	10.3	67.9	....	....	....	....	....	....
	Laclede □	3	10	12.0	....	20	12.4	....	4	11.3	....
	Lafayette □	6	29	11.6	74.5	50	14.1	80.0	10	9.6	68.3
	Lawrence □	10	18	10.2	72.5	26	14.2	79.1	11	6.2	63.2
	Lewis □	1	20	10.5	65.1	....	....	....	....	....	....
	Lincoln □	2	14	11.8	72.5	14	12.5	76.6	13	11.2	68.3
	Linn □	3	15	12.9	74.8	18	15.2	75.0	12	11.0	74.7
	McDonald □	1	21	13.3	85.3	....	....	....	....	....	....
	Macon □	1	10	14.2	72.3	....	....	....	....	....	....
	Marion □	2	15	10.0	....	15	11.4	....	15	8.5	....
	Mercer □	1	44	11.5	75.5	....	....	....	....	....	....
	Miller □	2	17	12.5	71.3	17	15.4	82.2	17	9.7	60.4
	Moniteau □	1	10	12.1	74.3	....	....	....	....	....	....
	Monroe □	3	19	12.0	69.8	20	13.1	71.1	17	10.8	68.5
	Montgomery □	8	16	8.8	60.2	26	11.4	75.4	9	3.6	59.5
	Morgan □	1	11	9.3	....	....	....	....	....	....	....

	New Madrid □	4	16	11.3	74.8	28	11.8	74.7	6	10.7	73.8
	Newton □	7	15	12.7	74.8	20	19.8	78.8	2	10.0	68.7
	Nodaway □	6	30	11.1	72.7	47	15.9	77.4	18	8.0	65.1
	Ozark □	1	4	18.3	.....	.....	.....	.....	.....	.....	.....
	Perry □	1	22	9.8	73.6	.....	.....	.....	.....	.....	.....
	Pettis □	5	20	10.8	71.6	27	12.9	74.2	14	8.4	68.7
	Phelps □	3	9	14.0	.....	11	15.4	.....	8	13.2	.....
	Pike □	6	22	12.1	68.7	56	14.4	76.3	3	10.2	60.9
	Platte □	5	31	10.3	71.2	44	11.3	74.0	16	8.6	66.3
	Polk □	2	24	12.4	76.9	27	13.2	79.3	20	11.5	74.5
	Pulaski □	1	12	18.3	86.1	.....	.....	.....	.....	.....	.....
	Putnam □	2	6	14.6	.....	6	15.9	.....	6	13.4	.....
	Ralls □	1	21	8.1	.....	.....	.....	.....	.....	.....	.....
	Ray □	1	34	10.5	68.3	.....	.....	.....	.....	.....	.....
	St. Charles □	4	19	11.9	76.1	29	14.4	77.1	15	10.3	75.0
	St. Clair □	6	13	12.8	74.2	24	17.4	76.0	6	9.0	72.0
	St. François □	1	11	11.8	67.7	.....	.....	.....	.....	.....	.....
	St. Louis □	5	20	10.4	.....	43	15.7	.....	5	6.6	.....
	Saline □	7	23	11.5	74.2	47	12.7	77.5	13	10.6	69.3
	Schuyler □	1	13	13.2	72.6	.....	.....	.....	.....	.....	.....
	Scotland □	1	19	14.3	75.8	.....	.....	.....	.....	.....	.....
	Scott □	2	9	11.3	.....	9	13.3	.....	9	9.2	.....
	Shannon □	2	9	12.0	.....	9	13.1	.....	9	10.9	.....
	Shelby □	4	18	11.5	67.5	30	15.5	69.3	10	8.3	65.7
	Texas □	2	15	12.4	70.3	20	12.8	71.2	10	12.0	69.4
	Vernon □	4	21	11.0	66.1	26	12.7	72.6	13	8.1	58.7
	Warren □	5	20	11.4	75.7	25	15.2	83.2	13	9.4	71.1
	Wayne □	2	23	11.1	.....	29	11.4	.....	17	10.7	.....
	Webster □	3	17	10.4	.....	31	12.0	.....	9	8.9	.....
	Wright □	8	18	15.7	77.8	20	17.0	80.6	16	13.4	74.9
Averages, etc		324	20	11.7	73.5	64	19.8	86.1	2	3.6	57.8
Montana	Dawson □	1	12	13.8	79.7	.....	.....	.....	.....	.....	.....
	Gallatin □	1	29	13.1	77.1	.....	.....	.....	.....	.....	.....
	Lewis and Clarke □	1	15	18.6	81.6	.....	.....	.....	.....	.....	.....
	Yellowstone □	1	25	11.9	72.8	.....	.....	.....	.....	.....	.....
Averages, etc		4	20	14.4	77.8	29	18.6	81.6	12	11.9	72.8
Nebraska	Cheyenne □	2	13	15.7	.....	14	17.3	.....	12	14.0	.....
	Dakota □	1	37	17.0	80.2	.....	.....	.....	.....	.....	.....
	Lancaster □	2	20	11.9	74.4	20	13.1	75.7	20	10.6	73.0
	Nemaha □	3	32	12.7	76.4	33	13.3	78.5	32	12.2	74.0
	Pawnee □	2	51	8.8	.....	58	9.1	.....	43	8.5	.....
	Richardson □	1	17	15.0	78.2	.....	.....	.....	.....	.....	.....
	Saunders □	1	25	12.7	76.9	.....	.....	.....	.....	.....	.....
	Washington □	1	34	13.0	78.6	.....	.....	.....	.....	.....	.....
Averages, etc		13	29	12.9	76.9	58	17.3	80.2	12	8.5	78.0

Table showing mean analyses and maxima and minima of the beets examined in the chemical laboratory of the United States Department of Agriculture during 1897, arranged alphabetically by States and counties—Continued.

State.	County.	Number of samples.	Averages.			Maxima.			Minima.		
			Weight.	Sugar in the beet.	Purity coefficient	Weight.	Sugar in the beet.	Purity coefficient	Weight.	Sugar in the beet.	Purity coefficient
			Ounces.	*Per cent.*		*Ounces.*	*Per cent.*		*Ounces.*	*Per cent.*	
Nevada	Esmeralda □	2	25	17.5	81.1	27	17.6	81.8	22	17.3	80.4
	Humboldt □	10	21	18.8	83.1	34	20.8	84.5	8	16.3	82.2
	Lander □	1	10	20.3	85.5	....	....	....	....	....	....
	Lyon □	3	19	17.6	79.6	20	18.0	80.1	19	16.9	79.0
	Washoe □	4	10	18.2	....	15	20.0	....	4	17.1	....
	White Pine □	1	8	16.0	75.4	....	....	....	....	....	....
Averages, etc	....	21	18	18.3	81.4	34	20.8	85.5	4	16.0	75.4
New Jersey	Atlantic □	2	24	14.8	81.9	38	17.6	87.2	10	12.0	76.5
	Burlington □	1	17	18.7	83.7	....	....	....	....	....	....
	Camden □	2	22	12.9	80.0	28	14.1	82.2	16	11.6	77.7
	Cumberland □	2	9	15.8	....	9	16.2	....	9	15.4	....
	Essex □	7	17	13.3	79.2	22	14.9	83.0	14	9.8	67.8
	Mercer □	7	20	11.5	79.3	34	13.6	83.1	13	8.6	76.2
	Ocean □	8	8	16.4	86.3	11	18.5	90.1	5	12.6	82.5
	Warren □	2	20	14.9	87.6	24	15.6	88.6	16	14.2	86.6
Averages, etc	....	31	16	14.2	81.4	38	18.7	90.1	5	8.6	67.8
New Mexico	Mora □	3	13	17.2	82.0	14	18.5	86.2	11	16.5	78.2
New York	Albany □	2	19	14.0	....	19	16.0	....	19	12.0	....
	Broome □	4	22	15.1	82.8	29	16.1	87.1	15	12.8	76.6
	Cattaraugus □	15	18	15.1	81.9	28	17.6	86.7	8	11.8	73.0
	Chautauqua □	45	21	16.6	82.7	48	20.0	86.2	10	10.2	75.0
	Chenango □	3	16	15.4	78.7	20	15.5	83.8	13	15.3	70.8
	Columbia □	1	20	14.7	81.5	....	....	....	....	....	....
	Dutchess □	4	16	17.3	85.1	18	22.6	89.1	18	14.5	82.7
	Erie □	37	19	15.9	83.9	39	19.2	90.6	5	9.7	66.6
	Fulton □	2	24	15.4	83.6	26	16.6	84.4	21	14.1	82.7
	Herkimer □	1	16	16.5	78.9	....	....	....	....	....	....
	Lewis □	2	21	13.9	77.8	22	14.3	79.4	20	13.4	76.2
	Livingston □	8	20	16.8	79.8	25	18.2	83.9	16	14.4	76.7
	Madison □	8	14	17.3	78.1	20	20.2	81.3	8	15.0	74.8
	Monroe □	3	23	13.1	79.8	27	15.9	85.2	21	13.1	72.7
	Niagara □	9	28	14.5	81.9	38	16.6	88.7	16	12.1	76.6
	Oneida □	22	14	13.6	81.8	67	17.2	88.2	6	9.7	71.2
	Onondaga □	7	17	17.5	83.2	25	19.5	83.4	9	15.5	82.1
	Ontario □	22	17	15.0	83.4	20	16.8	87.8	13	12.5	73.5

	Orleans □	8	27	16.7	85.4	34	17.5	86.7	16	15.2	84.5
	Otsego □	8	24	13.2	80.9	37	14.8	82.1	17	11.3	78.8
	St. Lawrence □	3	34	13 1	...	30	15.9	...	30	11.1	...
	Schuyler □	1	25	13.8	82.4	...	...	...	...	...	...
	Steuben □	2	24	17.0	85.5	24	17.3	85.7	24	16.7	85.3
	Suffolk □	1	24	16.9	83.0	...	...	...	...	...	...
	Wayne □	8	23	14.5	81.2	39	17.5	87.2	18	13.5	77.5
	Westchester □	4	10	12.1	...	16	13.9	...	7	10.0	...
	Yates □	15	23	12.7	79.6	50	17.1	88.6	8	9.0	73.2
Averages, etc	...	225	21	15.0	82.4	67	22.6	90.6	5	9.0	70.8
North Carolina	Cherokee □	2	36	7.1	...	36	7.6	...	29	6.5	...
	Davidson □	2	18	8.8	...	20	9.2	...	15	7.4	...
	Mecklenburg □	1	20	11.9	...	...	...	...	...	...	...
	New Hanover □	1	17	10.2	72.8	...	...	...	...	...	...
	Rowan □	1	27	10.6	77.7	...	...	...	...	...	...
Averages, etc	...	7	23	9.1	75.3	36	11.9	77.7	15	6.5	72.8
North Dakota	Benson □	1	17	10.8	...	...	...	...	...	...	...
	Pembina □	1	39	10.6	...	...	...	...	...	...	...
	Richland □	1	30	11.6	81.2	...	...	...	...	...	...
	Walsh □	1	26	9.1	...	...	...	...	...	...	...
Averages, etc	...	4	28	10.5	...	39	11.6	...	17	9.1	...
Ohio	Allen □	1	33	13.3	74.8	...	...	...	...	...	...
	Auglaize □	1	16	7.4	...	...	...	...	...	...	...
	Ashtabula □	4	24	15.3	84.1	33	16.2	87.6	17	13.9	78.5
	Brown □	2	21	11.9	71.4	23	13.5	73.5	19	10.3	69.2
	Champaign □	2	21	13.9	79.7	22	14.3	80.2	20	13.5	79.2
	Clark □	2	14	13.2	...	18	16.0	...	10	10.4	...
	Defiance □	1	14	17.0	86.4	...	...	...	...	...	...
	Delaware □	1	33	14.7	80.6	...	...	...	...	...	...
	Fairfield □	2	33	13.2	75.9	48	13.9	76.8	18	12.5	74.9
	Fayette □	1	24	15.4	80.9	...	...	...	...	...	...
	Fulton □	4	23	13.8	83.7	26	16.0	85.3	16	8.9	81.6
	Greene □	1	32	11.3	76.6	...	...	...	...	...	...
	Hardin □	3	17	14.3	81.9	20	15.6	84.5	14	13.4	78.4
	Henry □	1	16	16.2	78.3	...	...	...	...	...	...
	Hocking □	2	19	13.1	75.3	20	13.9	77.2	17	12.3	73.3
	Jefferson □	1	12	17.7	79.1	...	...	...	...	...	...
	Licking □	2	18	13.3	81.7	16	13.5	82.0	10	13.0	81.4
	Lucas □	1	22	16.0	82.0	...	...	...	...	...	...
	Morrow □	2	36	14.5	71.1	49	16.6	79.0	23	12.4	63.1
	Ottawa □	1	29	5.6	...	...	...	...	...	...	...
	Paulding □	10	24	13.1	76.5	63	17.3	85.3	9	9.5	65.4
	Preble □	1	12	13.3	...	...	...	...	...	...	...
	Putnam □	1	16	12.3	80.6	...	...	...	...	...	...
	Seneca □	1	19	17.0	81.7	...	...	...	...	...	...
	Shelby □	1	43	14.5	79.6	...	...	...	...	...	...

Table showing mean analyses and maxima and minima of the beets examined in the chemical laboratory of the United States Department of Agriculture during 1897, arranged alphabetically by States and counties—Continued.

State.	County.	Number of samples.	Averages.			Maxima.			Minima.		
			Weight.	Sugar in the beet.	Purity coefficient	Weight.	Sugar in the beet.	Purity coefficient	Weight.	Sugar in the beet.	Purity coefficient
			Ounces.	*Per cent.*		*Ounces.*	*Per cent.*		*Ounces.*	*Per cent.*	
Ohio	Stark □	3	23	14.9	....	39	16.3	....	12	14.2	....
	Summit □	2	20	13.4	73.8	24	16.0	84.4	15	10.8	63.1
	Trumbull □	1	19	15.0	79.3	....	....	....	....	....	....
	Van Wert □	1	25	11.0	70.6	....	....	....	....	....	....
	Washington □	2	40	11.8	77.7	40	12.8	82.7	39	10.7	72.7
	Wayne □	8	16	14.7	83.2	26	17.9	89.9	9	12.0	77.8
	Wood □	2	18	15.7	78.5	20	18.7	79.5	15	12.6	77.4
Averages, etc	....	68	22	13.8	79.1	63	18.7	89.9	9	5.6	63.1
Oklahoma	Woodward □	1	10	11.8	72.5	....	....	....	....	....	....
Pennsylvania	Allegheny □	13	18	13.8	77.0	25	18.4	86.2	10	7.1	72.3
	Crawford □	3	25	13.9	75.8	33	17.0	78.7	19	12.3	72.9
	Cumberland □	22	12	12.2	79.6	20	17.3	89.2	6	8.6	65.0
	Elk □	2	16	13.0	77.4	17	13.5	78.5	16	12.5	76.3
	Erie □	7	28	15.8	82.5	45	17.8	86.5	13	13.5	77.8
	Lawrence □	2	16	16.8	79.9	19	17.6	80.4	14	16.1	79.3
	Lebanon □	1	24	14.4	79.0	....	....	....	....	....	....
	Mercer □	2	34	15.4	83.7	34	15.6	84.6	34	15.1	82.8
	Perry □	2	31	15.7	82.2	40	17.3	85.3	22	14.1	79.1
	Potter □	1	18	18.0	81.1	....	....	....	....	....	....
	Union □	1	10	19.6	....	....	....	....	....	....	....
	York □	8	25	13.9	80.2	43	14.5	82.7	16	13.7	77.4
Averages, etc	....	59	18	13.8	79.5	45	19.6	89.2	6	7.1	65.0
Rhode Island	Washington □	2	21	11.9	74.2	23	12.3	76.7	18	11.4	71.6
South Carolina	Abbeville □	1	13	9.3	....	....	....	....	....	....	....
	Berkeley □	1	21	7.5	....	....	....	....	....	....	....
	Charleston □	3	29	9.4	....	31	8.0	....	10	3.8	....
	Edgefield □	1	15	11.4	....	....	....	....	....	....	....
	Greenville □	2	21	12.6	....	25	13.1	....	17	12.0	....
	Lexington □	1	16	7.4	....	....	....	....	....	....	....
	Pickens □	2	16	13.5	....	22	13.7	....	10	13.3	....
	Sumter □	2	12	11.2	....	12	11.5	....	12	10.9	....
Averages, etc	....	13	17	9.9	79.9	31	13.7	....	10	3.8	....

South Dakota	Beadle □	1	19	14.3							
	Lincoln □	1	14	13.4	80.0						
	Meade □	1	12	15.1							
	Yankton □	2	20	16.5	85.3	22	17.5	87.6	18	15.4	83.0
Averages, etc		5	17	15.1	83.2	22	17.5	87.6	12	13.4	80.0
Tennessee	Knox □	8	4	12.1		7	13.5		1	10.6	
	Maury □	4	16	11.5	72.6	24	14.9	74.1	10	8.9	69.8
	Warren □	2	24	9.5		28	10.6		20	8.3	
	Washington □	1	10	10.9	72.6						
	Weakley □	2	20	5.7		21	5.7		18	5.6	
Averages, etc		17	11	10.8	71.9	28	14.9	74.1	1	5.6	69.8
Texas	Denton □	1	9	13.5							
	Erath □	1	47	11.1							
	Grayson □	1	28	13.0	80.1						
	Hopkins □	1	12	8.8							
	Hunt □	1	6	13.4							
	McLennan □	1	5	13.0							
	Reeves □	4	30	13.6	76.7	33	14.7	79.8	14	11.3	75.1
	Wise □	1	13	11.5	72.3						
Averages, etc		11	22	12.6	76.5	47	14.7	80.1	5	8.8	72.8
Utah	Boxelder □	3	25	11.7	78.4	27	13.4	81.4	22	10.2	78.1
	Cache □	3	17	11.5	78.8	24	15.3	80.0	10	9.1	77.5
	Davis □	3	20	14.0	83.0	26	16.2	85.4	15	10.8	80.2
	Sanpete □	13	21	14,5	81.0	43	16.6	88.2	10	11.1	77.3
	Sevier □	4	16	14.9	78.8	21	16.1	82.0	10	12.9	74.3
	Utah □	6	14	16.7	84.8	16	20.2	90.5	11	13.5	79.2
	Weber □	3	29	13.1	79.3	36	14.9	85.3	16	10.3	70.6
Averages, etc		35	20	14.3	81.1	43	20.2	90.5	10	9.1	70.6
Vermont	Addison □	1	47	10.0							
	Caledonia □	1	29	16.9	85.0						
	Chittenden □	1	9	16.3	86.3						
	Franklin □	1	10	12.7	79.3						
	Lamoille □	1	30	13.2	81.8						
	Windham □	3	16	14.7	85.5	24	15.9	86.9	11	14.0	83.3
Averages, etc		8	22	14.2	84.1	47	16.9	86.9	9	10.0	79.3
Virginia	Albermarle □	1	10	9.7	65.4						
	Appomattox □	2	11	11.2		11	14.3		10	8.1	
	Augusta □	2	17	10.6		20	13.6		13	7.5	
	Bedford □	2	34	6.5		48	7 4		20	5.6	
	Caroline □	2	32	11.1	77.2	40	12.2	82.6	24	9.9	71.7
	Carroll □	1	15	15.4							
	Charles City □	1	19	12.2	77.6						

Table showing mean analyses and maxima and minima of the beets examined in the chemical laboratory of the United States Department of Agriculture during 1897, arranged alphabetically by States and counties—Continued.

State.	County.	Number of samples.	Averages.			Maxima.			Minima.		
			Weight.	Sugar in the beet.	Purity coefficient	Weight.	Sugar in the beet.	Purity coefficient	Weight.	Sugar in the beet.	Purity coefficient
			Ounces.	*Per cent.*		*Ounces.*	*Per cent.*		*Ounces.*	*Per cent.*	
Virginia	Fairfax □	2	25	12.4	79.9	31	12.4	83.8	19	12.4	76.5
	Fluvanna □	1	19	11.1	78.5						
	Goochland □	2	14	13.7	75.4	14	14.0	75.8	13	13.4	74.9
	Hanover □	1	23	13.1	73.3						
	Henrico □	1	24	6.7							
	James City □	1	24	12.4	81.8						
	King William □	1	13	13.7	80.9						
	Loudoun □	1	7	15.4	72.7						
	New Kent □	1	13	12.3	73.3						
	Northampton □	4	20	11.6	77.5	26	12.5	79.4	16	10.9	76.2
	Orange □	1	21	15.5	76.4						
	Princess Anne □	1	19	11.5	78.9						
	Warren □	5	31	10.9	73.0	49	14.7	76.5	22	6.3	69.2
	Wythe □	1	2	12.2							
Averages, etc.		34	21	11.6	76.2	49	15.5	83.3	2	5.6	65.4
Washington	Chehallis □	4	48	7.9		66	9.8		36	5.8	
	Clarke □	1	23	13.5							
	King □	2	25	11.8	81.1	32	11.9	83.0	17	11.6	79.1
	Kitsap □	1	58	11.0	76.2						
	Lincoln □	5	18	14.6	74.0	25	19.9	81.0	9	9.1	67.0
	Pierce □	1	33	13.0	81.4						
	San Juan □	1	18	14.4	78.3						
	Skagit □	6	26	12.7	76.4	48	15.3	83.4	16	9.9	74.3
	Whatcom □	2	23	11.3	77.5	25	12.9	83.3	20	9.6	71.6
	Yakima □	11	24	17.0	87.0	33	19.1	89.7	13	15.0	84.5
Averages, etc.		34	27	13.7	80.7	66	19.9	89.7	9	5.8	67.0
West Virginia	Grant □	1	53	13.5	83.0						
	Hardy □	1	20	11.9	69.1						
	Monroe □	9	18	16.6	81.8	30	18.9	88.8	6	13.6	75.3
	Morgan □	2	8	14.		8	14.5		7	14.1	
	Summers □	1	16	12.3	78.2						
Averages, etc.		14	19	15.4	80.4	53	18.9	88.8	6	11.9	69.1
Wisconsin	Ashland □	1	20	12.7	75.2						
	Clark □	1	14	13.9	85.4						

	Dane ☐	31	11	16.4	84.8	21	19.5	88.2	5	13.4	80.5
	Fond du Lac ☐	1	34	12.7	78.7	....	....	....	....	....	....
	Monroe ☐	1	32	11.5	71.4	....	....	....	....	....	....
	Outagamie ☐	1	8	17.2	86.9	....	....	....	....	....	....
	Racine ☐	3	34	15.4	82.6	38	15.9	83.9	29	15.0	80.9
	Rock ☐	1	20	13.2	78.6	....	....	....	....	....	....
Averages, etc		42	15	15.8	83.3	38	19.5	88.2	5	11.5	71.4
Wyoming	Albany ☐	5	12	18.7	86.7	26	22.3	92.1	6	12.2	77.8
	Bighorn ☐	6	20	18.7	82.2	26	22.7	87.2	13	12.0	70.2
	Converse ☐	9	26	17.8	82.2	60	24.3	86.3	12	15.6	77.7
	Crook ☐	1	5	17.1	....	....	....	....	....	....	....
	Fremont ☐	1	24	12.5	72.0	....	....	....	....	....	....
	Johnson ☐	3	26	11.3	76.1	33	13.4	76.9	14	9.1	75.2
	Laramie ☐	4	17	16.0	83.8	24	17.1	86.9	9	14.7	79.5
	Natrona ☐	2	11	18.5	....	13	19.6	....	8	17.3	....
	Sheridan ☐	3	12	17.9	....	13	19.6	....	9	16.2	....
Averages, etc		34	19	17.2	82.3	60	24.3	92.1	5	9.1	70.2

STUDY OF THE ANALYTICAL DATA.

In further elucidation of the data contained in the preceding tables a brief discussion of them for each State is appended, supplemented by a summary of those secured by the experiment stations in the several States.

ARIZONA.

The samples from Arizona consist of one from Apache County, and six from the agricultural experiment station in Pima County. In the foregoing tables the averages of weight are given to the nearest ounce to avoid the fractions of an ounce, which would necessarily increase the space required for printing. Inasmuch as the weight of the cut beet is so easily varied by a slight difference of the position of the knife in cutting, it is evident that this method of estimation is practically sufficient.

In the analytical data obtained from Arizona, as will be seen by referring to the preceding data, the mean weight of the beets examined was 23 ounces and the mean percentage of sugar in the samples 9.3. On account of the poor quality of the beets, the purity of the juices was not determined. The highest observed percentage of sugar in the beet was 12 and the lowest 7.6.

The following report of his investigations and observations in regard to the sugar beets grown in Arizona, during the season of 1897, was made by Robert H. Forbes, chemist of the Agricultural Experiment Station of Arizona.

RESULTS OF EXPERIMENTS WITH SUGAR BEETS IN ARIZONA FOR 1897.

By R. H. FORBES, Chemist.

Briefly stated, the average for 157 analyses of beets from all over the Territory is 8.56 per cent of sugar in the juice, with a purity of 61.8. At first glance these are discouraging figures indeed, but taken as they stand they are misleading, and their true significance can only be gotten at by examining the whole series of analyses for differences due to the effect of such important factors as care and skill in growing, different kinds of soil, differences of climate found in various localities and at different times of the year, and the variety of beets planted.

In order to show the results of careful cultivation upon the quality of the beets, I have divided the samples received from Salt River Valley into three lots.

The first lot consists of 13 samples grown by Dr. Claflin on the experimental substation grounds near Phœnix. These beets were given the most excellent care. The second lot consists of 24 samples obtained from 12 growers near Phœnix, Glendale, and Mesa. These beets received a fair amount of care during growth, but on the average were probably not as carefully attended to as Dr. Claflin's 13 samples. The third lot consists of 60 samples from the same localities, but which were cared for scarcely at all excepting for an occasional irrigation. The results speak for themselves. Dr. Claflin's 13 samples averaged 11.23 per cent of sugar in the juice with a purity of 68.3. The 24 cultivated samples from other growers averaged 9.42 per cent of sugar in the juice, with a purity of 66.3. The 60 neglected samples gave 8.35 per cent of sugar in the juice, with a purity of 53.4.

These figures confirm the well-known fact that intelligent and skillful care is essential in beet culture; more so, I dare say, than in the production of any other great staple, and careless or ignorant treatment of our vegetable thoroughbred will inevitably end in disaster. The sugar beet is no exception to the well-known rule that plants, which have been developed through cultivation, if neglected or allowed to run wild, quickly return to their former primitive condition.

Because of the unusual facility with which the sugar beet returns to its former unprofitable condition, it is evident that beet culture is a high art, and in this country the more intelligence is required in its treatment because the conditions are in many ways unusual, and the rules which are successfully applied in other countries must be changed or modified here.

In a general way, however, we may insist that deep and thorough preparation of the soil, careful irrigation, and repeated cultivations and hoeings as long as the crop will permit are no less essential here than elsewhere.

The effect of climate is also perceptible in our analyses. Samples have been received from St. Johns, St. Joseph, Holbrook, Duncan, Buckeye, Thatcher, Skull Valley, Tombstone, Taylor, Fort Thomas, and other more elevated or more northerly points. Almost without exception, the beets from these places were much above the average in richness and purity. The richest samples we have as yet received came from St. Joseph and contained 16.3 per cent of sugar in the juice, with a purity of 81; 17 samples received from the above places averaged 12.37 per cent of sugar in the juice, with a purity of 75.5.

In order to make the comparison more rigid, we select the Kleinwanzlebener variety only from among them, and find that 7 samples average 12.4 per cent sugar, with a purity of 76.3, as against 10.22 per cent sugar and a purity of 67.82 for this same variety in Salt River Valley.

Knowing the great influence of temperature upon the composition of the beet, it is difficult to lay these differences to any other cause than the cooler temperature of these higher and more northerly localities.

It is a matter of regret that arable land is so scarce in these parts of the Territory. Our observations, however, may guide us in obtaining better results in warmer localities, and in this way: Most of the Salt River Valley plantings were made in March and April, so that almost from the start the plants were subject to the hot summer weather, the temperature throughout the months of June, July, August, and September being much above the point generally regarded as most favorable to sugar beets. Now, it is possible that by planting earlier in the year a cooler temperature may be secured for the first three or four months of the life of the plants. Of course the risk from frost will be increased, but that there is some possibility of success in the plan is suggested by the fact that on June 14 we analyzed a sample of beets from Fowler Brothers, near Phœnix, which gave 15.2 per cent of sugar in the juice, with a purity of 76. The seed for this lot was planted February 12 and the beets were probably not mature.

We can not safely draw conclusions from a single instance, but the high percentage and purity in this extremely early sample are suggestive of the possible advantage in early planting.

Selecting the Kleinwanzlebener beets received from the northern places and comparing them with those obtained from Phœnix, Glendale, Tempe, and Mesa, in the Salt River Valley, we obtain the following results:

Showing effect of climate.	Average weight of beets.	Sugar in juice.	Sugar in beets.	Purity coefficient.
Kleinwanzlebener:	*Ounces.*	*Per cent.*	*Per cent.*	
From more northerly or elevated localities, 14 samples...	18	13.35	12.35	78.8
From Salt River Valley, 18 samples........................	18.2	10.48	9.69	69.5

The average mean monthly temperatures for Phœnix, Prescott, and Fort Thomas during several years past are shown in the following table. Phœnix is in the Salt River Valley, Prescott represents the cooler northern parts of the Territory from which beets were received, and Fort Thomas is in the fertile, irrigated portion of Graham County, in Southeastern Arizona.

	Mean temperature.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
Phœnix	49	54	61	67	74	82	90	88	80	70	61	55
Prescott	34	38	44	51	59	66	74	72	65	54	42	39
Fort Thomas	47	48	55	61	70	79	86	83	75	62	49	44

Finally, as to the soil, it is much more difficult to trace any connection between the quality of beets produced and the numerous varieties of soil, for which this region is famous and on which they have been grown. Fortunately, however, we have recently completed the analysis of a series of twenty representative Salt River Valley soils and certain general characteristics of the soils of this region have been determined.

From a chemical point of view the following statements may be made about five of the most important soil constituents, viz, potash, lime, nitrogen, phosphoric acid, and humus.

Potash is everywhere present in abundant quantities. We have found from 0.47 to 1.96 per cent in our samples, the lower figure being ample for a fertile soil.

Lime also is present in great sufficiency, the samples showing from 0.57 to 4.2 per cent.

Nitrogen, however, is deficient almost everywhere, the average for the series being 0.048 per cent, and in only two instances rising above 0.10 per cent, which is considered to be a needful amount to insure nitrogen fertility.

This deficiency probably affects the richness of sugar beets less than it does their size. It is well known that an excess of nitrogen produces beets of an enormous size, but of very poor quality. In one instance we received a beet weighing 5 pounds, which had been grown on heavily manured and abundantly irrigated soil. The sample gave only 1.7 per cent of sugar in the juice, with a purity of 23. This result was probably due, in part at least, to excessive nitrogen.

The small average size of the beets received, however, points to a poverty of nitrogen in the soil for this crop. This will hold for other crops as well as beets, and I am told that in one case near here two neighboring orange orchards were planted, one on virgin mesa soil, the other on plowed alfalfa ground. It is stated that the latter orchard has prospered far more than its neighbor. This was doubtless due to the nitrogen which alfalfa and other leguminous crops contribute to the soil. In selecting beet ground, therefore, other things being equal, it would be well in this region to choose that which has previously been in alfalfa.

In support of this view I would state that Dr. Claflin's samples were grown on ground that had previously been in alfalfa, so that his excellent record may have been due in part to this cause.

Phosphoric acid is usually present in sufficiency, though never very abundant. In some cases a serious lack of phosphoric acid has been noted. The average for the valley is 0.13 per cent. It is stated that the effect of phosphoric acid in beet culture is to increase the sugar and hasten maturity. It is supplied to advantage in connection with nitrogen, this combination tending to increase the size of the beets and also maintain their richness.

This desirable combination of nitrogen and phosphoric acid is found in guanos and in bone superphosphates, and it is probable that the application of these fertilizers will, so far as beet culture is concerned, greatly improve the soils of this region. The question of cost, of course, enters here, but it is one which must in any case soon be solved. At Chino, Cal., with an exceedingly fertile soil, the need of commercial fertilizers is already felt, after the lands having been cropped for five or six years.

Barn manure is of value for beets only after other crops have been grown on the land, and the manure thereby thoroughly incorporated with the soil. If applied just before planting the beet seed, it will prove injurious both to the stand of plants and the quality of the product.

Humus, or vegetable matter, is deficient in all arid soils, our own among the number. Humus and lime are valuable largely because they impart better tilling qualities to the soil, give it greater water-holding power, and lessen the tendency to hardness when dry. Humus results from barn manure, and the application of this material with suitable precautions should be beneficial.

As to alkali and its effect upon beets, it may be said that when the plants are once established in thrifty growth they will stand more alkali than most other crops. It has been observed also at Chino that the quality of the beets is not impaired by alkaline ground. It is probable, however, as a matter of opinion, that young plants are injured by the crust formed on the surface of the soil through the action of alkali, and this may account in part for the exceedingly poor stand of plants obtained in most of the experiments this year. Almost without exception, the reports state that the seed did not come up well or that the young plants died. This difficulty may possibly be overcome by planting earlier in the year, by using more and better seed, and by taking more care to keep the surface soil loose during the germination of the seed and the first weeks of plant growth. Salt River Valley is not excessively alkaline; much less so, it is stated, than the Pecos Valley in New Mexico, where beet culture is now attempted.

So much for the result of one season's experimental work. The lessons we have learned are: (1) That here as elsewhere sugar beets must be grown with the utmost care; (2) that the cooler portions of the Territory, so far as observed, produce better beets than the warmer localities, and that experiments should be made as to what early planting will do in these warmer localities; (3) that the Kleinwanzlebener variety, so far as yet known, yields the best results in Arizona; and (4) that the soils of the valley stand in need of nitrogen and organic matter, possibly phosphoric acid also, and that previous occupation of the ground with alfalfa or other means of fertilization should be secured.

Though many of the results are unfavorable, the occasional successes that have been secured show that there is ample reason for a continuance of the work.

If, during the next year, a half dozen first-class farmers of this valley will each put in an acre of Kleinwanzelebener beets early in the year, on ground that has been in alfalfa, and will care for them as they ought to be cared for, I believe that we may have something much more favorable to report on this subject.

Further details of the above experiments with beets are published in Bulletin No. 26 of the Arizona experiment station, issued in December, 1897.

The poor results obtained in Arizona are somewhat surprising, although in general it may be said that the climate of Arizona is too warm for securing the best results. The remarks made by Mr. Forbes in regard to careful culture should be given due consideration. The probabilities are, however, that inasmuch as the beets in Arizona were all grown with irrigation, the application of the water was of such a character as to prevent, in some respects, the development of the highest saccharine content. It may be remarked in general, in regard to the beets grown with irrigation, that much is yet to be learned in regard to the manner of supplying the water, the time at which it is to be applied, and the quantity which is to be used. It would be expected that the ideal conditions of moisture could be secured by irrigation, and yet in practice the results have not been the most encouraging.

This has been true in regard to the growth of beets in Utah and New Mexico under irrigation. There is no factor connected with the sugar-beet industry which is of more practical interest than a careful study of the conditions under which irrigated beets should be grown. The fertile soils of the arid regions are undoubtedly able to produce large crops of beets under irrigation, when the proper conditions are understood. Complaints have also been made in respect of the effects of alkali upon beets in these soils, and also of insect pests. It is important that a study be made of the bacteria, molds, and insect pests of sugar beets, together with the effects of the alkali. After allowing for all these conditions, however, it must be confessed that the Arizona data are somewhat disappointing, and unless great improvement can be made there is little prospect of the industry being established on a secure foundation in that region.

ARKANSAS.

Arkansas lies so far south of the beet belt as to make a discussion of the possibilities of beet growing in that vicinity unnecessary. Only two samples were received from the State, and as might be expected, these do not show any very favorable qualities. A few general remarks may be made about growing beets in warmer climates than those best suited to obtaining the highest grade of beets, namely:

First, that it is quite possible to get fine harvests of beets with favorable tonnage per acre,

Second, that it is possible to grow beets containing quantities of sugar which would have made them valuable for manufacturing purposes several years ago, before the beet reached its present high state of development, and

Third, that such beets could probably be grown with great profit for stock-feeding purposes in all these localities. The full value of the beet and beet pulp will be discussed in a separate portion of this report.

The average weight of the two samples received from Arkansas was 18 ounces, and the average content of sugar in the beet 11.3 per cent.

CALIFORNIA.

California is recognized as the principal beet sugar producing State in the Union. Only one sample of beets was received from this State, and it had a weight of 26 ounces and contained 16.8 per cent of sugar. All of the coast valleys of California are favorably situated, in respect of temperature, for the production of sugar beets, and the same may be said of certain lands, the limits of which are not yet well defined, in other parts of the State. Even in the Sacramento Valley, as far inland as the point of junction with the San Joaquin River, where the temperature is higher than that considered best for beets, it has been found that good beets can be grown. In experiments conducted on Union Island, near Stockton, Cal., during the years 1884–85, under direction of the chief chemist of the Department of Agriculture, very encouraging results were obtained, both in the quantity and the character of the beets produced. These beets were grown upon the reclaimed lands of the delta of the San Joaquin at its junction with the Sacramento River. The lands were protected from overflow by strong levees, but the conditions were not theoretically the most favorable for the production of high-grade beets.

Unfortunately, however, large portions of the coast lands, by reason of their contour, are not well suited to the cultivation of beets. On page 90 of Bulletin No. 5 of the Division of Chemistry, published in 1885, the following observation is made: "In the interior and eastern divisions of California only the high Sierra regions have a temperature low enough for beets, and in that locality there is no land adapted to beet culture. The beet region of California, therefore, is confined to the coast valleys." This statement may have to be modified to some extent by reason of the data mentioned above from Union Island. These observations are corroborated by the analyses made by Director Hilgard, during 1897, of beets grown in Sacramento County. This locality adjoins Union Island, where the experiments conducted by the Department of Agriculture were made. The average size of the beets examined by Director Hilgard was satisfactory, and the content of sugar in the beets was a little over 16 per cent, with a high purity reaching almost 85 for a whole series of analyses. These data show that in the Sacramento Valley, at least where the temperature is somewhat higher than that regarded as most favorable, beets of fine sugar-producing qualities can be grown. After a careful personal study of the climatic and soil conditions in California, made in 1884, it is stated on page 100 of Bulletin No. 5 of the Division of Chemistry that there are in California about 5,830 square miles of land suitable to beet culture, provided the whole of it could be supplied with a sufficient quantity of water. Even if only one-third of this area should be found eventually fit for the culture of beets, it would be possible for the State of California alone to produce nearly 500,000 tons of beet sugar and still practice a proper rotation of crops. In view of the fact that the beet-sugar industry has been so carefully studied in California, both by the agricultural experiment station and by those engaged in the manufacture of sugar, it is not necessary here to dwell further upon the possibilities of its extension in that State.

COLORADO.

The number of samples received from the State of Colorado at the Department of Agriculture was 174. The average weight of the beets received was 20 ounces, the mean percentage of sugar in the beet 13.6, and the mean purity 76.7. The conditions which obtain in Colorado are so different from those of the Eastern States as to warrant a detailed discussion of the data. This, however, in the present condition of affairs, would be somewhat premature. It is advisable to wait until a more thorough agricultural survey of the State be made, under the immediate supervision of the agricultural experiment station. When the analytical table of the data received from Colorado is consulted, it is seen that most remarkable differences exist in the returns from the different counties. Since in most cases only a very few samples have been received from any given county, it is not fair to make any judgment of the possibilities of any one county from data of so limited a nature. The great variations in altitude in the State, causing sharp differences of temperature, must also be taken into consideration. In addition to this, it is fair to presume that the samples have all been grown under irrigation, and it is impossible, in such data as are collected from the farmers, to determine with any certainty what the proper conduct of the irrigation should be. In general, the data are entirely satisfactory, especially in respect of content of sugar. As regards the mean purity of the juices, the data are somewhat unsatisfactory, since it falls more than three points below the minimum of good beets. This may be due to the great amount of mineral salts which the soils of Colorado contain, and to the well-known property of the sugar beet of absorbing these salts from the soil. For this reason, it may be suggested that in many cases cultivation of the sugar beet could be advantageously practiced, not alone on account of the profit in the beet itself, but because of the improvement in the soil which would result from the extraction of the alkaline materials. Among the counties where the samples have been somewhat numerous and the results most encouraging may be mentioned Boulder, lying to the northwest of Denver and mostly within the favorable thermal area, where the average content of sugar in the beet was over 15, and the purity nearly 81. This most favorable result was obtained with exceptionally large beets, the average weight of which was 31 ounces. This fact makes the data even more valuable and suggestive.

Another county where the data were extremely favorable, although the number of samples was only two, is Delta, a county lying within the theoretical thermal area, and where the average size of the samples was 20 ounces, the average content of sugar over 17, and the purity 80.5.

Another favorable result may be reported from Garfield County, although the average size of the beets is a little low. The mean percentage of sugar in the beets was 16.6, and the purity 83.2. This county also lies mostly in the thermal belt.

In contrast with the above should be cited the returns from Logan County, showing not only small beets, but exceptionally low contents of sugar and purities. Logan County, nevertheless, is contained almost wholly within the thermal belt, which is most favorable to the growth of beets. The poor results obtained must therefore be due to causes which are not made known.

Upon the whole, the data from Colorado are exceedingly encouraging and lead to the belief that there are many parts of that State where, with proper conditions of tillage and irrigation, the sugar beet industry may be established with profit.

In connection with the work done by the Department of Agriculture, it is interesting to consider the report of the director and chemist of the agricultural experiment station of Colorado at Fort Collins:

BRIEF REPORTS REGARDING SUGAR BEET EXPERIMENTS FOR THE YEAR 1897, AT THE COLORADO STATE AGRICULTURAL COLLEGE.

Chemical section.

The work of the chemical department on sugar beets can be summarized briefly as follows:

We began taking weekly samples on September 2. The varieties represented were Vilmorin, two plots; Kleinwanzlebener, two plots; Leon Brand,[1] one plot; and Imperial, one plot. The amount of sugar in the beets was determined from week to week. We did not find a very rapid increase as the season advanced until the beets approached maturity, when we observed a sudden increase of about 3.5 per cent. Our samples varied greatly in their sugar content, but agreed in indicating that the crop in this country was not sufficiently matured to yield marketable beets before the middle of October. The average of the beets analyzed subsequent to this date, debarring one lot, the most of which were grown under unfavorable conditions, and a few samples which were clearly unmarketable beets, is 14 per cent, the range being from 10 per cent to 18.25 per cent of sugar. The coefficient of purity has ranged from 70 to 89, and has averaged 80.7. We believe the average percentage of sugar given to be high enough, but the coefficient of purity—80.7—is lower than the actual coefficient rather than higher.[2]

Respectfully submitted.

WILLIAM P. HEADDEN,
Station Chemist.

Agricultural section.

(From Report of the Director.)

In a general way it can be said that the results of this season's work are very favorable to the establishment of the beet-sugar industry in Colorado. The following figures are to be judged in the light of the statements that come from all the beet-sugar manufacturing States of the Union, that the season of 1897 was especially unfavorable to the industry. If in this poor year Colorado can make such a good showing, what may we expect of her in ordinary or favorable years?

The above report of the chemist of our Experiment Station gives the figures for the beets raised on the College Farm. But few analyses were made here of beets raised elsewhere, since the failure to get into our new chemical building last fall left the Chemical Department in poor shape for doing much outside work.

Practically all the analyses of Colorado beets not grown at Fort Collins were made in the Chemistry Division of the Department of Agriculture at Washington. It has seemed best to give here merely a summary with reference to our local conditions.

For the purpose of sugar-beet raising Colorado may be divided into five sections:

(1) The valley of the South Platte and its tributaries.

(2) The divide south of Denver, and the plains region where beets are grown without irrigation.

(3) The valley of the Arkansas River.

(4) The valley of the Grand River.

(5) The San Luis Valley.

All these, except the second, use irrigation. There are two features of the raising of sugar beets that require special study—namely, the quality of the beets when they are ripe and the time of the year when they reach that degree of ripeness. The earlier in the season they reach a profitable degree of sugar and purity the longer season the factory will have to manufacture the crop, and the larger the amount of crop that can be handled by a factory of a given size.

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[1] This variety is unknown to me.—H. W. W.

[2] It is not clear what is meant by this expression.—H. W. W.

Many tests were made of sugar beets dug in September, but only a few showed beets suited for use in sugar making. Nevertheless, the fact that a few samples, even by September 18, exceeded 12 per cent sugar and a purity of 80, shows that when our farmers are more used to growing sugar beets they can bring them to maturity several days, and probably two weeks, earlier than the average crop of 1897. With the first days of October the crops ripened rapidly.

The following table presents a summary of the season of 1897, with reference to the quality of the beets, and the time of ripening in different parts of Colorado:

Section of State.	Samples dug between Oct. 1 and 10.		Samples dug between Oct. 10 and 15.		Samples dug after Oct. 15.	
	Sugar.	Purity coefficient.	Sugar.	Purity coefficient.	Sugar.	Purity coefficient.
	Per cent.		*Per cent.*		*Per cent.*	
The valley of the South Platte	14.1	80.7	14.6	81.1	15.4	81.1
The divide and the plains	12.5	73.7	15.1	80.6	14.8	78.3
The valley of the Arkansas	....	....	13.1	77.9	15.3	81.9
The valley of the Grand	16.3	83.6	....	....	....	....
The San Luis Valley	13.7	79.2	12.4	78.5	14.8	80.3

IDAHO.

The number of samples received at this laboratory from the State of Idaho was only seven, representing two counties. The average weight of the beets received was 21 ounces, the average content of sugar therein 15.5 per cent, and the average purity 79.4. Both in respect of size of the beets and content of sugar the results are very encouraging. The average coefficient of purity is almost up to the minimum standard, and doubtless could be improved later on. The alkalinity of the soil, which has been mentioned in connection with the lowering of the average in Colorado, is doubtless active in Idaho. There are large areas in Idaho where the thermal conditions are favorable, but they are detached from the main thermal belt crossing the continent. There are two centers of thermal conditions in Idaho which serve as nuclei for determining the conditions most favorable. One of these lies almost wholly in the State, and Boise City may be regarded as the center of it, and the other extends into the western and northern part of the State from the State of Washington. In general, it may be said that the thermal conditions in Idaho, if they alone are to be considered, are sufficiently favorable for the culture of the beet, in so far as the growing season is concerned. The data obtained, while meager, are sufficiently encouraging to warrant a more thorough survey of the State, and also the belief that the conditions for the successful establishment of the sugar industry may be found wherever the character of the soil, in respect of contour and fertility, and the facilities for irrigation and other factors favorable to the growth of the sugar beet and the manufacture of sugar can be secured. The report of the chemist of the station contains much valuable information in respect of the sugar-beet industry in the State of Idaho, and is herewith appended:

RESULTS OF EXPERIMENTS IN IDAHO.

In the first place, the results of the past season are quite disappointing and unsatisfactory, due to several causes which will be eliminated largely in the experiments of next year.

The climatic conditions of Idaho are quite varied, the growing season opening several weeks earlier in South Idaho, along the Snake River and in the Boise Basin, than along the Clearwater or in North Idaho. The seed furnished gratis to this station by the Department of Agriculture arrived late, and before it could be distributed—May 4 to June 2—the season was well advanced, hence the seed that was planted either failed of germination, or the young plants were killed by severe climatic changes of heat and drought, or of cold and wet soil, which latter condition prevailed in the Palouse region. Much of the seed sown in our station plats failed to grow. The stand was irregular, weak, and of poor quality, so that the tonnage per acre could not be estimated with any degree of reliability. It is therefore omitted from the tables.

Seed was mailed to 114 farmers, representing 41 different sections of the State, yet samples of beets for analysis were received at this Department from only 20 farmers, representing 13 localities. This apparent apathy on the part of our farmer friends is explainable in part. In many cases the seed did not reach its destination, or when planted it failed to germinate, or the young plants were destroyed by insects or jack rabbits. In a few cases there was not sufficient interest manifested in the experiment to induce proper cultivation of the young plants, therefore no samples worthy of shipment were grown.

Sugar-beet growing is a new industry to the American farmer, and he has yet to learn that the ordinary farm methods are not always applicable and sufficient to grow and mature a typical sugar beet. The Idaho rancher is not an exception. He has yet to learn the value of intensive methods, from the preparation of the seed bed to the marketing of his crop. The neglect to plow deeply, to pulverize finely, to place the seed with care, to thin the plants judiciously, to cut out the weeds, withal to cultivate and hoe the growing plants regularly, resulted in partial or entire failure of the experiment. The sugar beet is a thoroughbred, and must be given care in keeping with its regal characteristics if high sugar content and purity are to be attained. The successful sugar-beet grower has learned that the sucrose is practically hoed into the root. This knowledge and its application our farmers evidently were not in possession of, or the number of samples forwarded would have been greatly augmented. It is a matter of education, however, which will be overcome in time by the dissemination of information through the press, the station bulletin, and closer competition induced by immigration from older States, where better methods of farming prevail.

The 41 samples analyzed averaged in sugar content 15.17 per cent; in purity, 87.55. The 20 samples grown by the Station gave in sugar 15 28 per cent; in purity, 92.55. The 21 samples grown elsewhere averaged 15.07 per cent of sugar, and 82.78 in purity. The highest and lowest results gave 19 and 10.2 per cent in sugar; and 95.10 and 81.81 purity, respectively.

OTHER SUGAR BEET DATA NOT HITHERTO GIVEN TO THE GENERAL PUBLIC.

During the fall of 1894, 192 analyses of sugar beets were made by the Station, which gave an average of 13.7 per cent of sugar and a purity of 76.08 degrees. Some of the samples were large, others had been frozen, still others were immature, while a few varieties were not at all adapted to our soil and climate. This reduced an otherwise much higher average. Excluding about 20 samples, the remainder, 55 samples of Vilmorin's Improved gave an average of 11.77 per cent of sugar and a purity of 75.55 degrees.

Forty-four samples of Kleinwanzlebener beets averaged 14.16 per cent of sugar with a purity of 82.80.

Thirty samples of Imperial averaged in sugar 14.1 per cent, in purity, 85.42.

Ten samples of French Red Top gave an average of 13.65 per cent of sugar with a purity of 82.70.

The average of 10 samples of Lane's was 13.44 per cent of sugar with a purity of 81.69.

Eight samples of New Danish gave an average of 13.83 per cent of sugar and a purity of 81.81.

The highest and lowest percentages of sugar in each variety were as follows:

Variety.	Highest.	Lowest.
	Per cent.	*Per cent.*
Vilmorin's	16.6	14.4
Kleinwanzlebener	19.6	14.6
Mette	18.4	14.6
Imperial	18.2	10.6
Lane's	15.7	10.6
Red Top	15.9	10.7
Danish	15.2	10.8

The places represented in the experiment were the University of Idaho, Cœur d'Alene, Sand Point, Moscow, Kendrick, Lenville, Princeton, Cornwall, Genesee, substation at Grangeville, substation at Idaho Falls, substation at Nampa.

The average yield throughout the State was estimated at 20 tons per acre.[1]

ANALYSES OF BEETS GROWN IN 1895.

The experiments in sugar beets for 1895 were covered by 342 analyses of beets grown by the University of Idaho and by farmers residing near Grangeville, Nampa. Moscow, Weippe, Vollmer, Palouse, Spokane Bridge, Westlake, Starner, Newport, Salmonn, and Paris.

The average sugar content of the crop was 15.19 per cent; coefficient of purity, 79.91. In the analyses were included 15 samples of red or table beets. These 15 contained an average of 13.75 per cent of sugar in the juice and a coefficient of purity of 75.57.

Several analyses were made for the purpose of determining what bearing, if any, the size of the sample beet had upon the sugar content and purity. Among others I select four varieties, and submit the results without comment:

VILMORIN'S IMPROVED.

Size.	Weight.	Sugar in beet.	Purity coefficient.
	Ounces.	*Per cent.*	
1. Large	21.4	14.02	79.96
2. Medium	15.2	14.31	81.26
3. Small	7.8	14.07	78.58

FLORIMOND DESPREZ.

1. Large	28.7	14.35	83.95
2. Medium	16.5	14.46	84.00
3. Small	10.7	14.10	80.25

LANE'S IMPERIAL.

1. Large	24.1	13.62	80.92
2. Medium	13.3	13.69	82.17
3. Small	8.0	13.38	82.07

KLEINWANZLEBENER.

1. Large	26.0	14.00	84.13
2. Medium	17.0	14.06	84.72
3. Small	13.0	13.74	83.93

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[1] This estimate, as is usual in such cases, is doubtless too high.—H. W. W.

ANALYSES OF BEETS GROWN IN 1896.

The work of the year was confined very largely to the station, and consisted of a special effort in the way of growing typical sugar beets. The effect of deep and shallow plowing, regular cultivation, fertilization, and irrigation, as compared with the average treatment given the root under natural conditions as to soil, moisture, and cultivation, was noted. The seed bed was prepared and the seed sown from the 21st to the 30th of May. Very heavy rains prevailed on June 5 and again on June 9. All of the seed had germinated by June 11. The average per cent of stand June 5 was 10.7; June 24 it was 29; one month later it had reached 61.8 per cent. The crop was harvested and analyzed during October. The number of analyses made was 60; the per cent of sucrose in juice was 14.18; coefficient of purity, 77.30; yield per acre, 48,510 pounds.

The sugar-beet experiments connected with this station during 1894, 1895, 1896, and the inauguration of the work of 1897 were under the direction and control of the Agricultural Department, the chemist being responsible only for the analytical data. In July, 1897, under the redistribution of the powers of the station staff, the rather unsatisfactory data thus collected were assigned to the chemical department for compilation and publication, together with the power of supervision of such experiments in the future.

METEOROLOGICAL RECORD.

The better to understand the possibilities of the sugar-beet industry in the Palouse country of Idaho, as well as other experiments that may hereafter be undertaken by the station upon the "university farm," the following meteorological data are included in this report. We are under obligations to Prof. J. E. Bonebright, meteorologist of the station, for the results tabulated:

TABLE 11.—*Meteorological record for Moscow.*

Month.	Maximum temperature.	Minimum temperature.	Average temperature.	Humidity.	Rainfall.	Days fair.	Days clear.	Days cloudy.
1894.	°	°	°	*Per cent.*	*Inches.*			
April	76.0	25.0	47.40	76.0	1.38	8	7	15
May	86.0	30.0	57.40	63.0	1.53	7	15	9
June	84.0	32.0	62.00	74.0	1.23	3	19	8
July	93.0	40.0	78.00	65.0	.12	2	29	0
August	96.0	34.0	70.50	46.0	.25	3	26	2
September	85.0	32.0	58.80	72.0	.89	2	25	3
October	74.0	28.0	40.40	85.0	3.70	9	9	13
1895.								
April	76.0	26.0	48.10	70.0	1.30	5	12	13
May	81.0	30.0	51.90	68.0	2.17	2	22	7
June	96.0	33.0	59.40	52.0	.41	....	....	....
July	92.0	41.0	72.70	38.0	.90	1	29	1
August	94.0	33.0	74.50	47.0	.32	3	26	2
September	84.0	28.0	49.80	70.0	3.33	2	20	8
October	74.0	21.0	46.10	72.0	Trace.	2	27	2
1896.								
April	68.0	26.0	42.53	....	.57	12	10	8
May	84.0	31.0	46.50	85.5	3.60	4	13	14
June	92.0	34.0	61.10	61.7	2.21	0	30	0
July	97.0	14.0	70.41	55.6	.17	0	30	1
August	93.0	38.0	67.17	55.4	1.33	0	26	5
September	85.0	30.0	54.65	72.2	.81	0	22	8
October	76.0	28.0	46.33	....	1.07	2	17	12
1897.								
April	63.1	36.5	49.70	72.2	.40	0	19	11
May	78.8	88.8	....	....	1.20	0	21	10
June	65.6	46.0	53.80	77.4	2.72	0	25	5
July	82.0	48.5	70.00	45.4	.85	0	26	5
August	81.6	46.4	71.50	40.3	.35	0	30	1
September	69.9	38.4	59.20	77.6	1.67	0	22	8
October	66.4	36.4	....	....	1.10	3	22	6

ILLINOIS.

The samples received from the State of Illinois by the Department of Agriculture were 32 in number. The average weight of the samples was 17 ounces, percentage of sugar 13.1, and the purity 75.5. Twelve of these samples were from the northern, 8 from the central, and 12 from the southern belt.

When judged by the few samples analyzed by the Department of Agriculture, it is seen that Illinois presents an exception to the established rule, inasmuch as the beets grown in the northern belt are inferior to those grown in the central belt. The data, however, are not numerous enough to base any certain conclusions upon them, and the usual rule is established from the more numerous analyses conducted by the agricultural experiment station, as will be seen farther along. Summarized, the results obtained at the Department of Agriculture from the northern, central, and southern belts in Illinois are as follows:

Summary of analyses of sugar beets from Illinois.

[Compiled from analyses of the United States Department of Agriculture.]

	Number of samples.	Average weight.	Sugar in beets.	Purity coefficient.
		Ounces.	*Per cent.*	
Northern belt	12	19	12.6	76.2
Central belt	8	20	13.8	76.5
Southern belt	12	13	13.2	73.3

At the agricultural experiment station of Illinois, at Urbana, 312 samples of beets were received and analyzed. The following summary shows the analytical data and the distribution of the samples by counties:

Summary of analyses of sugar beets from Illinois, by counties.

County.	Number of samples.	Average weight.	Sugar in beets.	Purity coefficient.	County.	Number of samples.	Average weight.	Sugar in beets.	Purity coefficient.
NORTHERN BELT.					CENTRAL BELT.				
		Ounces.	*Per ct.*				*Ounces.*	*Per ct.*	
Stephenson	1	20	10.7	70.0	Kankakeo	8	24	12.9	79.3
Winnebago	2	18	13.4	75.8	Henderson	1	22	9.2	70.8
McHeury	1	19	15.1	84.3	Knox	4	20	11.0	75.1
Carroll	4	20	13.8	81.4	Stark	1	10	14.4	78.3
Whiteside	6	22	13.9	79.2	Peoria	4	24	13.0	80.1
Ogle	3	23	12.6	74.6	Marshall	1	18	14.3	83.9
Lee	8	16	13.8	80.6	Woodford	1	22	13.3	82.1
Dekalb	7	20	13.4	78.3	Livingston	3	17	14.0	82.9
Dupage	1	21	15.6	82.2	Iroquois	50	20	11.3	75.3
Cook	3	24	14.3	82.7	Hancock	1	17	10.6	64.0
Rock Island	1	16	14.9	82.5	Fulton	1	17	11.2	77.1
Henry	6	18	12.7	78.3	Tazewell	2	20	12.3	78.8
Bureau	3	33	10.5	76.5	McLcan	5	24	12.0	77.6
Lasallo	31	22	13.1	76.4	Ford	1	24	10.8	77.0
Kendall	2	14	13.8	82.8	Adams	4	17	12.4	75.5
Grundy	1	18	13.9	80.2	Mason	25	19	11.1	73.7
Will	23	28	12.9	74.6	Logan	4	29	9.8	69.6
Mercer	1	17	12.6	79.7	Dewitt	1	27	13.8	81.7

Summary of analyses of sugar beets from Illinois, by counties—Continued.

County.	Number of samples.	Average weight.	Sugar in beets.	Purity co-efficient.	County.	Number of samples.	Average weight.	Sugar in beets.	Purity co-efficient.
CENTRAL BELT—continued.					CENTRAL BELT—continued.				
		Ounces.	*Per ct.*				*Ounces.*	*Per ct.*	
Macon	1	18	8.0	64.9	Clark	4	11	13.6	73.9
Piatt	2	20	12.7	81.0					
Champaign	10	21	11.7	79.6	SOUTHERN BELT.				
Vermilion	2	19	11.3	75.2					
Pike	1	10	9.6	69.4	Effingham	1	10	12.6	74.6
Scott	1	10	9.7	64.3	Madison	15	21	10.3	74.0
Morgan	4	22	10.3	74.3	Bond	1	18	10.3	80.8
Sangamon	2	17	11.2	76.8	St. Clair	11	21	12.3	77.7
Christian	2	19	11.8	76.5	Washington	1	16	11.9	75.2
Shelby	3	21	10.9	71.9	Jefferson	1	14	12.1	85.0
Douglas	3	24	11.2	77.5	Wayne	1	16	14.3	77.0
Edgar	2	16	12.1	74.9	Clay	1	15	11.8	68.3
Calhoun	2	14	9.4	72.1	Edwards	1	15	8.7	58.7
Greene	3	14	8.5	68.3	Jackson	2	17	10.8	73.8
Macoupin	6	17	11.6	72.2	Saline	3	10	9.3	68.9
Montgomery	5	11	13.0	76.9					

The average weight of the beets received was 20 ounces, the mean percentage of sugar therein 11.9, and the mean purity 76.4. Distributed geographically into northern, central, and southern sections, we find each of the sections represented by the number of samples of the mean average composition indicated in the following summary:

Summary of analyses of sugar beets from Illinois.

[Compiled from the experiment station report.]

	Number of samples.	Average weight.	Sugar in beets.	Purity co-efficient.
		Ounces.	*Per cent.*	
Northern belt	104	22	13.2	79.3
Central belt	165	20	11.5	75.4
Southern belt	43	19	11.1	74.7
Average, etc	312	20	11.9	76.4

Here we see the regular rule illustrated, and the beets derived from the northern are superior in every respect to those from the central and southern belts. It is evident, however, judged by the data obtained during the present year, that Illinois is not so well adapted to the growing of high-grade beets as some of the States to the east of it. Nevertheless, it is quite certain that, with proper drainage, scientific cultivation and fertilization, and good culture, high-grade beets can be grown in many of the northern counties of Illinois, and it would probably be safe to say that for a distance of 100 miles from the boundary between Wisconsin and Illinois the sugar-beet industry could be successfully established where the conditions of soil and factors favorable to manufacture are suitable.

INDIANA.

One hundred and three samples were received at the Department of Agriculture from the State of Indiana, representing several different parts of the State, but mostly from the northern portions. The largest number of samples, however, from any one county was from Vanderburg, in the extreme southwestern part of the State. The average size of the beets from Indiana was small, the percentage of sugar in the beet fair, and the purity a little below the minimum for good beets. In general, the best beets were grown in the northern portion of the State, near or in the thermal beet belt, although a few samples received from the central and eastern parts of the State were very satisfactory. Among the counties furnishing the largest number of samples may be mentioned Henry, in the central eastern part of the State, from which 8 samples were received, having an average weight of 17 ounces, containing 13.1 per cent of sugar, with a purity of 78.5. The averages for Henry County in sugar and purity were almost exactly those for the whole State. Three samples from Marion County, in the central portion of the State, show excellent results, both in percentage of sugar and in purity, and having an average size of a pound. The best results are reported from Stark County, in the northwestern portion of the State, where the percentage of sugar was 15.7 and purity 81.8. The beets, however, from this region were small, the average size being only 12.8 ounces. The beets received from the agricultural experiment station were very much undergrown, the average weight being less than 7 ounces. The percentage of sugar in the beets was good—15.1—and the purity also above the minimum. The causes of the poor yield of beets are discussed farther on in the report of the chemist of the station. The largest number of beets from any one county was received from Vanderburg, namely, 40 samples. The people of this county have been particularly interested in the industry, and especially to Mr. H. Cordes are we indebted for the large number of samples received. In spite of the very fertile soil and other favorable conditions of culture, the beets had an average size of only 14 ounces, and both the percentage of sugar in the beet and the purity were below the minima. In general, it may be said of Indiana that the northern portions of the State, where the character of the soil is favorable, are best suited to the culture of the sugar beet, namely, those portions either lying in the area of favorable thermal conditions, or extending to a varying distance to the south thereof and covering the greater portion of the northern part of the State. The central counties of the State, judged by the few samples received, may also be expected to grow beets of fair quality. A more careful agricultural survey of the State is needed, and the data above are supplemented by the more valuable data collected by the agricultural experiment station under the supervision of the chemist, Mr. H. A. Huston.

NOTES ON SUGAR BEETS RAISED IN INDIANA IN 1897.

(From Report of H. A. HUSTON.)

The early part of the season was fairly favorable to the growth of the crop. In many cases, however, the beets were planted quite late and were much below normal size when the drought came on in August. From the middle of August until the end of the usual growing season very little rain fell. This tended to produce beets of high sugar content and small size. The popular interest in the subject has been much greater than in previous years and a much better return than usual was secured from the seed sent out.

At three points in the State parties are now engaged in placing contracts for sufficient acreage to insure a three years' supply of beets for a 300-ton factory. Reports from these localities indicate that the required acreage will be secured.

Nearly all farmers who have raised experimental crops of beets for the past few years report that they believe the crop would be a profitable one at $4 per ton. This estimate is based solely on their own experience with the crop.

The total number of samples analyzed at the agricultural experiment station of Indiana was 205. Arranged by counties, the following table gives the most important data connected with the analyses:

Tests of sugar beets grown in Indiana in 1897 under the direction of the Indiana agricultural experiment station. H. A. Huston and J. M. Barrett.

County.	Average weight.	Average per cent of sugar in juice.	Average purity.	Number of beets by counties.	County.	Average weight.	Average per cent of sugar in juice.	Average purity.	Number of beets by counties.
	Ozs.					*Ozs.*			
Lake □	51	8.3	68.0	1	Grant □	12	13.6	70.1	2
Porter □	12	13.7	84.0	2	Jay □	26	13.3	79.5	2
Laporte □	22	9.0	64.3	1	Fountain □	31	10.1	68.6	1
St. Joseph □	24	13.0	85.0	6	Clinton □	18	13.2	83.2	4
Elkhart □	12	14.8	83.6	7	Boone □	13	13.6	82.0	5
Lagrange □	12	16.6	87.4	1	Tipton □	20	13.5	82.3	11
Starke □	14	14.1	85.0	28	Madison □	33	9.2	70.2	1
Newton □	11	13.7	96.4	1	Randolph □	24	12.9	79.0	8
Jasper □	2	17.9	84.4	1	Parke □	8	10.2	56.7	1
Allen □	23	13.5	82.4	21	Marion □	17	12.7	83.5	1
Benton □	31	11.2	79.6	3	Hancock □	23	14.0	87.4	4
White □	20	10.3	66.0	1	Henry □	19	12.9	78.0	12
Cass □	17	12.1	77.2	4	Morgan □	14	13.9	82.8	3
Wabash □	14	13.0	77.8	4	Greene □	12	12.8	84.4	3
Huntington □	25	11.8	78.0	19	Jackson □	8	10.0	72.8	2
Warren □	18	12.2	83.0	1	Vanderburg □	15	10.6	77.7	36
Tippecanoe □	15	12.5	84.6	8					
Carroll □	11	12.4	82.0	5	Averages, etc	17.8	12.6	80.7	205

As will be seen above, nearly all the counties represented are in the northern part of the State. Only a few counties are represented in the central and southern portions of the State. Making an average of the results from the different counties by sections of the State, it is seen that they vary considerably, as is shown in the following summary:

Summary of results.

	Average weight.	Average per cent of sugar in juice.	Average purity coefficient.	Number beets.
	Ounces.			
Northern belt	18.9	13.3	81.9	97
Central belt	18.5	12.9	80.7	67
Southern belt	14.2	10.7	78.0	41

It is seen that there are considerable areas in the northern part of the State where both soil and climatic conditions are extremely favorable to the culture of the sugar beet. The proximity of these counties to Chicago insures a market for all the products of the factory. In many cases these counties are situated in or near the gas area of the State, so that fuel is comparatively cheap. All of them are within easy distance of the great coal fields of Indiana, and the supply of water and limestone is abundant. It is evident, therefore, that all the conditions favorable to the growth and manufacture of the beets exist in the northern part of the State of Indiana, and there is no reason to doubt the speedy foundation and healthy growth of the industry in that locality.

IOWA.

The thermal conditions for the growth of beets in Iowa are favorable over almost the whole of the State from north to south. The southern counties are probably a little too warm for the best results, and the northern counties too much exposed to severe cold weather during harvest time.

One hundred and thirty samples of beets were sent directly from Iowa to the Department of Agriculture for analysis.

In the results as tabulated by counties it will be observed that a great many of the counties are represented by a single sample, and therefore it is not possible to base any conclusions on the work done in respect of the possibilities of growth of beets in such counties. Benton County sent 6 samples, with an average weight of 16 ounces; 13.8 per cent of sugar in the beet, with a purity of 76.9. Clinton County furnished 5 samples. The beets were very small, averaging only 11 ounces. The content of sugar was high, namely, 16.8 per cent, and the purity low, 75.8. Greene County sent 39 samples of good size, namely, 21 ounces; rather low content of sugar, namely, 12.7 per cent, and a low purity, namely, 76.3. Guthrie County sent 6 samples of good size, namely, 23 ounces; rather low content of sugar, 12.5 per cent, with a purity of 78.8. The averages for the 130 samples from the State are as follows: Weight, 18 ounces; sugar in beets, 13.3 per cent; purity, 73.7.

Under the direction of the agricultural experiment station of the State, in cooperation with this Department, a large number of samples of seed was distributed, and 642 samples of beets sent to the station for analysis. Following is an abstract of the report of Prof. C. F. Curtiss, director of the Iowa station:

Total number of samples analyzed, 642.

One and seven-tenths per cent of the samples contained 17 per cent or more of sugar; 73 per cent of these had a purity coefficient of 80 or above, and 50 per cent of these samples weighed 14 ounces or above.

Four and three-tenths per cent of the samples contained 16 per cent and over of sugar and less than 17 per cent; of these samples 86 per cent had a purity coefficient of 80 degrees or above, and 2.9 per cent weighed 14 ounces or above.

Twenty-two and three-tenths per cent of the samples contained 14 per cent or over of sugar and less than 16 per cent; of these samples 50 per cent had a purity coefficient of 80 or above, and 62 per cent weighed 16 ounces or above.

Forty-one and four-tenths per cent of the samples contained 12 per cent and over of sugar and less than 14 per cent; of these samples 14.7 per cent had a purity coefficient of 80 or above, and 69 per cent weighed 16 ounces or above.

Sixty-nine and three-tenths per cent of the total number of samples contained 12 per cent or more of sugar.

The above percentages are based on the weight of the juice.

The mean weight of the samples received at the Iowa station was 19 ounces, the mean percentage of sugar in the beet 12.4, and the mean purity 76.6. The results by counties are given in the following table:

Analyses of sugar beets grown in Iowa and analyzed by the Iowa agricultural experiment station.

County.	Average weight per root.	Sugar.	Purity coefficient.	County.	Average weight per root.	Sugar.	Purity coefficient.
	Ounces.	*Per cent.*			*Ounces.*	*Per cent.*	
Adair	19	13.40	77.45	Johnson	20	12.54	76.98
Adams	21	13.26	75.30	Jones	17	14.05	77.52
Allamakee	20	14.26	78.87	Keokuk	23	14.06	76.46
Appanoose	8	16.11	82.80	Kossuth	25	12.58	77.26
Audubon	16	13.09	78.36	Linn	17	12.08	74.02
Benton	21	13.30	76.68	Louisa	10	12.65	74.54
Blackhawk	17	13.98	79.64	Lyon	19	14.07	79.33
Boone	17	13.83	76.81	Madison	18	12.55	74.34
Bremer	14	11.24	78.71	Marion	21	12.86	74.66
Buchanan	15	14.24	76.25	Marshall	22	12.51	74.85
Buena Vista	19	13.62	77.70	Mills	19	12.94	76.94
Butler	13	10.77	74.45	Mitchell	20	12.37	76.21
Calhoun	12	15.80	81.46	Monona	27	13.86	80.87
Carroll	22	12.34	75.51	Montgomery	25	12.33	76.52
Cass	22	12.03	75.34	Muscatine	20	14.44	80.92
Cedar	21	12.56	74.48	O'Brien	16	14.38	92.77
Cherokee	19	13.34	77.01	Osceola	14	14.16	81.48
Chickasaw	15	13.34	75.54	Page	23	12.56	74.22
Clay	17	12.08	74.06	Palo Alto	22	12.88	106.85
Clayton	23	13.48	78.47	Plymouth	26	12.49	79.39
Clinton	17	15.81	78.97	Pocahontas	20	11.76	78.46
Crawford	23	10.55	68.24	Polk	22	12.96	76.09
Dallas	23.	13.46	79.33	Pottawattamie	19	13.04	78.13
Davis	14	15.78	73.94	Poweshiek	20	12.87	77.52
Decatur	12	14.14	79.27	Ringgold	17	12.54	75.58
Delaware	18	13.23	75.76	Scott	16	13.73	76.59
Dickinson	21	12.81	75.16	Shelby	24	13.43	78.58
Dubuque	17	14.14	69.76	Sioux	28	12.44	73.79
Fayette	17	14.62	80.33	Story	22	12.30	76.51
Floyd	24	12.77	75.01	Tama	17	12.55	77.04
Franklin	17	12.62	73.23	Taylor	11	11.82	70.39
Fremont	19	12.15	71.37	Union	15	13.98	76.54
Greene	19	13.04	77.42	Wapello	19	13.70	76.74
Grundy	23	12.00	73.91	Warren	20	13.62	75.79
Guthrie	22	12.60	74.98	Washington	21	13.84	77.84
Hamilton	21	12.58	75.24	Wayne	13	15.15	70.92
Hancock	18	11.92	75.84	Webster	18	12.57	76.14
Hardin	19	12.88	77.01	Winnebago	22	12.21	76.87
Harrison	17	12.65	76.57	Winneshiek	19	13.57	76.42
Henry	26	14.24	78.64	Woodbury	20	12.72	74.34
Howard	18	13.33	77.48	Worth	18	13.34	78.77
Ida	21	12.79	77.49	Wright	15	12.22	75.48
Jasper	23	13.06	76.86				
Jefferson	12	12.36	76.27	Average	19	12.98	76.56

The results contained in the above table are not as satisfactory as would be expected from the location of Iowa in respect of thermal and other climatic influences. The poor results obtained are due either to the seasonal influences, which might have been particularly bad for the season in question, or to some unsuitability of the soil or climate to the production of high-grade beets. In general, it has been observed that soils particularly rich in humus and of a black color do not produce as high-grade beets as sandy and somewhat lighter-colored soils. The character of the subsoil and of the stratum underlying it must also be taken into consideration before we can have an idea of the condition of aeration of the soil and the possibilities of the roots of the beets extending to the proper depth. It is fortunate that the agricultural experiment station of Iowa will continue these experiments in a more careful manner and under more efficient control of the station or some of its representatives. It is evident that with the possible exception of the southern tier of counties a large portion of the State of Iowa with favorable soil conditions should produce beets of high saccharine strength. The causes which have depressed both the content of sugar and the coefficient of purity should be carefully investigated.

KANSAS.

Several years ago extensive experiments in growing beets in Kansas were made at Medicine Lodge, and accounts of the work are given in former bulletins on this subject. At that time it was stated, in discussing the results, that the climate of Kansas was particularly unfavorable to beet culture. The extremely dry weather to which much of the State is frequently subjected, in conjunction with the hot winds which sweep over the vast plains almost every year from the southwest, renders the growth of the beet extremely precarious. At times excellent beets can be grown; in fact, beets of fine character were produced at the time mentioned at Medicine Lodge. It is not to be expected, however, that from year to year beets of high grade can be grown in sufficient quantities to warrant the building of factories in the State. Nevertheless, considerable interest is taken in the work by the farmers in various parts of the State, and also by the agricultural college and experiment station. Forty-one samples were received by the Department of Agriculture. The average size of these samples was rather large, namely, 27 ounces. The sugar content was low, 11.4 per cent, and the purity quite low, 73.8. While it is evident that large quantities of sugar can be made from beets of this character, it is also plain, without argument, that such a quality of beets would not be able to compete with those grown in more favorable localities.

The agricultural experiment station of Kansas, in cooperation with the Department of Agriculture, also conducted a series of experiments and received for analysis 157 samples. A detailed report of this work will be found in the bulletins of the agricultural experiment station of Kansas, and the following summary sufficiently indicates the character of the results obtained. The number of samples analyzed was 157. The average net weight of the beets received was 17 ounces; the average content of sugar in the beets, 11.9 per cent, and the average coefficient of purity of the juice, 77. The percentage of the whole number of beets containing 13 per cent of sucrose or over was 15.2. The percentage of beets containing 13 per cent of sugar or over, having a coefficient of purity of the juice of 80 per cent or over, was 67. The percentage of beets containing 13 per cent and over of sugar and weighing 16 ounces or more, net, was 42.

The analyses made at the agricultural experiment station of Kansas have been consolidated and tabulated by counties. The table of analyses follows:

Summary of analyses of beets from Kansas.

[Compiled from report of experiment station.]

County.	Number beets in samples.	Number samples.	Average weight.	Cane sugar in juice.	Coefficient of purity.	County.	Number beets in samples.	Number samples.	Average weight.	Cane sugar in juice.	Coefficient of purity.
			Ozs.	*Per ct.*					*Ozs.*	*Per ct.*	
Allen	10	1	14	10.64	72.0	Lyon	14	2	16	13.29	79.5
Atchison	17	2	17	12.61	79.5	Marion	53	6	16	11.23	71.8
Barber	14	2	12	14.91	72.5	Marshall	49	5	25	12.20	79.4
Barton	4	1	34	10.35	74.0	McPherson	7	1	7	13.08	76.0
Bourbon	8	1	5	13.88	75.0	Montgomery	21	3	15	11.39	74.6
Brown	10	1	21	11.29	81.0	Morris	14	2	15	14.01	74.5
Butler	22	4	18	10.86	70.8	Nemaha	48	4	23	10.30	74.2
Chase	6	1	14	11.61	77.0	Osage	20	4	16	12.17	77.2
Cheyenne	10	1	17	12.14	79.9	Osborne	10	1	16	12.39	70.0
Clay	37	3	28	11.21	78.0	Ottawa	27	4	22	12.90	78.2
Cloud	93	9	20	11.65	79.2	Pawnee	8	1	4	8.52	70.0
Coffey	4	1	20	15.13	78.0	Phillips	21	2	19	12.16	79.5
Crawford	12	1	14 } 21	13.87	82.0	Pottawatomie	30	3	16	12.20	83.6
Do	3	1	28	......	......	Pratt	14	2	8	12.19	75.0
Dickinson	20	4	17	12.29	77.0	Rawlins	8	1	16	9.57	73.0
Doniphan	15	1	24	13.67	84.0	Reno	18	2	12	13.78	79.5
Douglas	11	2	20	12.48	77.5	Republic	49	4	18	10.69	74.5
Edwards	6	1	12	11.12	71.0	Rice	6	2	14	11.71	74.5
Elk	14	2	21	14.04	83.0	Riley	......	3	21	8.98	70.3
Ellsworth	5	1	17	......	......	Rooks	21	2	16	13.39	80.5
Finney	6	1	19	14.14	74.0	Rush	10	1	20	11.88	77.0
Franklin	6	1	16	11.86	77.0	Russell	12	3	10	11.49	71.0
Geary	6	1	13	9.51	70.0	Saline	16	2	9	15.78	84.0
Graham	31	3	18	12.83	76.0	Sedgwick	12	2	12	11.23	74.0
Grant	6	1	16	15.47	78.0	Shawnee	29	3	15	12.19	77.3
Harvey	6	1	5	......	......	Sheridan	20	2	21	11.59	78.5
Do	6	1	14	12.83	78.0	Smith	10	1	28	11.12	78.0
Jackson	14	1	20	11.17	73.0	Sumner	7	1	18	13.38	76.0
Jefferson	6	1	15	11.82	76.0	Waubaunsee	23	2	15	12.14	77.5
Jewell	40	4	19	11.12	77.3	Wallace	6	1	19	11.58	76 0
Johnson	14	2	18	14.23	83.0	Washington	99	10	27	10.79	75.2
Labette	3	1	20	8.76	67.0	Wichita	6	1	14	11.24	79.0
Lane	26	2	4	10.17	68.5	Wilson	36	5	14	13.12	81.0
Leavenworth	22	4	12	12.75	79.0	Woodson	10	1	7	14.32	73.0
Lincoln	16	3	28	11.38	79.6	Wyandotte	4	1	14	14.11	75.0
Logan	10	1	19	11.40	76.0						

The data obtained at the Kansas station corroborate in every respect those secured at the Department of Agriculture. It is evident that fairly good beets can be grown in Kansas, and there are doubtless seasons when exceptionally rich beets might be secured. In general, however, it may be said that there is no immediate prospect of the successful establishment of the sugar-beet industry in that State, unless it might be in some of the extreme western or northwestern counties, where irrigation might be practiced, and where the altitude is sufficiently high to secure a lowering of the temperature. One of the great causes of danger, however, is found in the hot southwest winds, which frequently blow over the State with disastrous consequences at the period when the crops are growing most rapidly. It will be seen that in many instances individual analyses obtained in Kansas are extremely satisfactory, as for instance, in Elk County, where two samples, including 14 different beets, showed an average weight of 21 ounces, an average content of sugar in the juice of 14 per cent, and an average purity of 83. Another sample is found in Saline County, where 16 beets, forming two samples, showed a sugar content of 15.8 per cent in the juice, with an average purity of 84. In this case, however, the beets were very much under size, the average weight being only 9 ounces. When, however, the data received from the counties are compared with similar data from the State of New York, the discrepancy observed is so great as to indicate, without further elucidation, the proper locality where the first development of the sugar-beet industry should be looked for.

In the light of our previous experiments, it must be evident that high-grade sorghum, developed from carefully selected seeds, has a better prospect in Kansas of being a profitable sugar-producing plant than the sugar beet.

KENTUCKY.

Only a few samples, with the exception of those sent by the experiment station, have been received from Kentucky. This State being situated far south of the theoretical sugar-beet belt, it is not to be expected that the results of the analyses would be particularly encouraging. The mean weight of the six samples received was 16 ounces, the mean percentage of sugar 11.9, and the purity 71.5. The six samples included four from the experiment station. The beets received were small, and the percentage of sugar only a trifle under the minimum which is advisable for profitable sugar making. The purity, however, is excessively low, and this seems to be characteristic of beets grown too far south, the purity coefficient usually falling in a more rapid proportion than the content of sugar.

Large numbers of samples were received from the experiment station in addition to those analyzed above, which were grown upon the special plot, which will be mentioned later on, and under the most favorable conditions of culture. The beets which were sent to the Department were of good size and mostly of a favorable shape, but the analytical data were very disappointing, falling a great deal lower than was expected. Nine samples of White Improved Imperial Elite, planted May 8 and harvested December 9, had an average weight of 33 ounces, with 4.9 per cent of sugar. Three samples of original Kleinwanzlebener had an average weight of 23 ounces, with 10.8 per cent of sugar. Sixteen samples of Vilmorin's Improved had an average weight of 25 ounces, with 6.4 per cent of sugar. Thirty-nine samples of the Demesmay variety had an average weight of 29 ounces, with 5.3 per cent of sugar. All of these beets were somewhat overgrown, but not sufficiently so to account for the extremely low percentage of sugar. A large additional number of samples had been selected for analysis, but the results of the preceding analyses were so discouraging as to render the further prosecution of the analytical work unnecessary. This subject will be mentioned again when the experiments in the specially cultivated plots with high-grade seeds are discussed.

MARYLAND.

All the analyses of the samples of beets grown in Maryland were made in the laboratory of this division, the agricultural station at College Park not having undertaken any work of this kind. The whole number of samples received from the State was 29. The mean size of the beets was 19 ounces, the mean percentage of sugar in the beets 11.4, and the mean purity of the juices 79.1. In respect of size, the samples from Maryland are about the mean. The purity of the juice is almost up to the minimum standard, but the percentage of sugar in the beet is about 0.6 less than is advisable for manufacture.

In regard to climatic conditions, as has been before intimated, the State of Maryland occupies a somewhat peculiar position. There is a considerable area along the eastern shore, next to the ocean, where the average summer temperature is 71°. In the western part of the State, after a long deflection to the north, the isotherm of 70° may again be found. Lying immediately south of the isotherm of 71°, in the northern portion of Maryland, are found some very fine valley lands where the conditions of culture may be considered favorable. These lands are underlaid by limestone, which in many cases comes to the surface. Theoretically they are a little too warm for the most successful culture, but lying so near the favorable thermal belt there may be reasonable hopes of successful culture in many localities. In the western portion of the State, where the thermal conditions are favorable, we find the mountain ranges, and the low temperature of the summer is due to the high elevation. The quantity of table lands upon the tops of the mountains, however, is not sufficiently great to warrant the expectation of the founding of a great industry. There is no doubt, however, of the possibility of growing very rich beets on these table lands. In general it may be said that the State of Maryland is not very favorably situated for the culture of sugar beets, but there are circumscribed localities within the State where it is desirable to conduct further experiments. It is therefore earnestly hoped that the agricultural experiment station of the State will make a more careful agricultural survey of the possibilities of the culture of sugar beets therein.

MICHIGAN.

The southern peninsula of Michigan is favorably situated for the culture of sugar beets, both in respect of thermal conditions and rainfall. The soil is also for the most part well suited to sugar-beet culture. In going northward, however, it becomes more sandy until finally the pine regions are reached, where a soil without fertilization would not be sufficiently rich to produce large crops. The well-known tendency of a sandy soil, with proper meteorological conditions, to produce beets of a high purity is well illustrated in the samples which have been received from Michigan. In all, 450 samples from the State were sent to this laboratory for analysis, 400 of them being from Saginaw County and grown under the supervision of Messrs. Higgins & Lenders.

In regard to the results from particular counties, attention should be called to the fact that the samples from Allegan were all enormously overgrown, the average weight of the beets being 62 ounces and the corresponding content of sugar and the coefficient of purity low. The results from Calhoun County, in the southern part of the State, are particularly favorable, the average weight of the samples being 17 ounces, average content of sugar in the beet 15.8, and the average purity 83.2. The greater part of the samples having come from Saginaw County, the average data for this county are almost the same as those of the State, with the exception that the purity is considerably higher. The average composition of the 400 samples from Saginaw County was as follows: Average weight, 22 ounces; sugar content in the beet, 14.8 per cent, and purity, 83.3. For the whole State—450 samples—the average weight was 22 ounces, average sugar content 14.7 per cent, and average purity 81.1.

The agricultural experiment station of Michigan, in cooperation with the Department of Agriculture, also made an extensive series of investigations, a résumé of which is given below:

RESULTS BY COUNTIES OF THE CULTIVATION OF SUGAR BEETS IN MICHIGAN IN 1897.

The following table is given containing the number of samples sent to the station from each county, the average per cent of sugar in the juice, and coefficient of purity of all samples sent. Seed was distributed in sixty-eight counties, and from the table below it will be seen that samples have been received from sixty-four of them. The average per cent of sugar in the juice of beets of the whole State, when grown on the proper kind of soil and from the right kind of seed, is 16.40, and the coefficient of purity is 84. An average of 16.40 per cent of sugar for the whole State, far exceeding the best districts in France and Germany, is both surprising and gratifying.[1]

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[1] These data are obtained by omitting from the table the analyses of samples which were known to have been grown under unfavorable conditions.—H. W. W.

Analyses of sugar beets grown in Michigan and analyzed by the Michigan agricultural experiment station.

County.	Total number of samples.	Sugar in juice.	Coefficient of purity.	Samples rejected for bad soil or seed.	Number of samples on right soil and proper seed.	Sugar in juice in such samples.	Coefficient of purity.
		Per cent.				*Per cent.*	
Alger	1	14.22	80	0	1	14.22	80
Allegan	3	15.67	86	0	3	15.67	86
Alpena	2	15.01	80	0	2	15.01	80
Antrim	2	15.97	82	0	2	15.97	82
Arenac	8	16.77	85	0	8	16.77	85
Baraga	1	14.10	76	0	1	14.10	76
Barry	4	14.90	81	0	4	14.90	81
Bay	10	15.53	84	1	9	16.00	84
Berrien	3	17.83	87	0	3	17.83	87
Branch	3	16.62	84	0	3	16.62	84
Calhoun	6	15.82	84	0	6	15.82	84
Cass	2	15.44	82	0	2	15.44	82
Charlevoix	7	17.58	87	0	7	17.58	87
Clare	2	16.80	84	0	2	16.80	84
Clinton	4	15.89	84	1	3	16.05	86
Crawford	1	15.25	81	0	1	15.25	81
Eaton	5	17.50	83	0	5	17.50	83
Emmet	1	15.02	82	0	1	15.02	82
Genesee	6	14.75	82	1	5	16.14	84
Grand Traverse	7	15.75	82	2	5	15.91	83
Gratiot	6	16.09	83	0	6	16.09	83
Hillsdale	2	16.71	84	0	2	16.71	84
Huron	6	17.47	85	0	6	17.47	85
Ingham	36	16.43	87	1	35	16.53	87
Ionia	4	16.36	82	0	4	16.36	82
Iosco	6	13.18	77	1	5	14.22	79
Iron	1	18.18	80	0	1	18.18	80
Isabella	4	14.09	78	1	3	16.41	82
Jackson	7	19.74	74	5	2	18.16	86
Kalamazoo	17	15.45	82	3	14	15.87	82
Kalkaska	2	16.91	83	0	2	16.91	83
Kent	16	15.55	83	2	14	15.85	84
Lapeer	2	17.71	84	0	2	17.71	84
Leelanaw	3	18.77	89	0	3	18.77	89
Lenawee	5	15.96	85	0	5	15.96	85
Livingston	2	14.34	80	0	2	14.34	80
Mackinac	1	16.22	85	0	1	16.22	85
Macomb	11	16.11	82	2	9	16.91	83
Manistee	6	17.09	84	0	6	17.09	84
Mason	5	16.54	85	0	5	16.54	85
Mecosta	4	16.67	84	0	4	16.67	84
Menominee	6	16.58	84	0	6	16.58	84
Midland	2	17.62	86	0	2	17.62	86
Missaukee	1	15.79	84	0	1	15.79	84
Monroe	2	16.41	84	0	2	16.41	84
Montcalm	2	17.64	83	0	2	17.64	83
Muskegon	9	16.03	85	0	9	16.03	85
Newaygo	13	16.11	81	1	12	16.54	81
Oakland	7	15.29	83	1	6	16.26	83
Oceana	11	16.54	86	0	11	16.54	86
Ontonagon	4	15.15	79	0	4	15.15	79
Osceola	2	16.55	85	0	2	16.55	85
Otsego	1	18.00	90	0	1	18.00	90
Ottawa	14	16.47	83	0	14	16.47	83
Saginaw	127	15.99	84	4	123	16.13	84
St. Clair	31	17.53	83	1	30	17.64	83
St. Joseph	1	12.16	76	0	1	12.16	76
Sanilac	11	18.15	86	0	11	18.15	86
Shiawassee	4	16.89	83	0	4	16.89	83
Tuscola	1	18.94	89	0	1	18.94	89
Van Buren	4	13.82	80	0	4	13.82	80
Washtenaw	4	16.10	84	0	44	16.10	84
Wayne	9	16.12	84	1	8	17.08	85
Wexford	9	14.59	79	1	8	15.25	81
Total	493				465		
Average		16.08	83			16.40	84

Five samples from Oceana County are not included in results of analyses, because they were dried and damaged by keeping.

Interesting data in regard to cost of culture were obtained at the Michigan station. The plats were planted on the 8th of May, and harvested on the 6th of October. After throwing the dirt away from the beets by a plow they were pulled by hand and the leaves and stems removed. Owing to the deep subsoiling and thorough preparation of the ground, the beets were found wholly embedded in the soil, none of them having been pushed above the surface. The average weight of the beets before the removal of the necks was about 2½ pounds. The following table gives the total labor, calculated to 1 acre, required for growing and harvesting the beets:

	Man and team.	Man.
	Hours.	*Hours.*
Plowing and subsoiling	12.00	....
Harrowing	3.75	....
Marking	.80	....
Planting	....	3.25
Cultivating	15.00	....
Thinning and hoeing	....	75.90
Harvesting	4.60	130.75
Total	36.15	209.90

The hand labor in harvesting was performed by boys at 8 cents an hour. The work of hoeing and thinning was performed by men at 12½ cents an hour. The cost of team work is computed at 25 cents an hour for man and team. On the above basis, the total cost of planting, cultivating, and harvesting an acre of beets at the Michigan Experiment Station was $29.40. The yield per acre, the percentage of sugar in the juice, and the purity for each variety grown are shown in the following table:

Variety.	Yield per acre.	Sugar.	Purity.
	Pounds.	*Per cent.*	
Wohanka	23,615	15.22	83
Improved Kleinwanzlebener	25,678	16.40	91
Original Kleinwanzlebener	27,368	18.27	94
Government Kleinwanzlebener	25,648	17.78	94
La Plus Riche	29,205	18.78	92
Government Kleinwanzlebener	32,327	17.78	94
Hoerning's Improved	24,500	15.20	89
Floto's Improved	20,200	13.21	88
Kleinwanzlebener on muck	....	12.96	75

Full details of all the experiments conducted in Michigan by the agricultural experiment station are found in Bulletin No. 150 of that station, issued in December, 1897, by Director C. D. Smith and Chemist R. C. Kedzie.

The study of the two sets of data secured at the Department of Agriculture and by the agricultural experiment station of Michigan is sufficient to demonstrate the fact that the southern peninsula of Michigan has great possibilities for the development of the sugar-beet industry. When it is remembered that the most of those who grew the samples had had no previous experience in the matter, that no systematic fertilization was attempted, and that in many instances the soil was improperly prepared, the remarkably favorable results obtained are the more convincing. It is evident that all the southern portion of the Southern Michigan Peninsula, in conjunction with the northern part of Indiana, forms an area in which the future will see a remarkable development of the sugar-beet industry.

MINNESOTA.

Forty-nine samples from the State of Minnesota were received for analysis at the laboratory of the Department of Agriculture. The mean weight of the samples received was 24 ounces, the mean percentage of sugar in the beet 11, and the mean purity coefficient 79.2.

Great variations are shown in the samples received from different parts of the State. One of the best series of results was obtained from Freeborn County, in the southern part of the State, from which twelve samples were received, having an average weight of 20 ounces, an average content of sugar in the beet of 14.1 per cent, and an average coefficient of purity of 82.3.

Another good series of samples, though less in number, was from Ottertail County, in the western part of the State, from which four samples were received, having an average weight of 23 ounces, a mean content of sugar in the beets of 14.9 per cent, and a mean coefficient of purity of 82.1. The general average from the State was lowered by a large number of very poor samples, which evidently had been grown under extremely unfavorable conditions.

The period of growth in Minnesota, while a little short, is nevertheless favorable from other considerations, especially in the southern and eastern portions of the State. Toward the northwestern portion of the State the rainfall is somewhat uncertain, and the autumn is perhaps a little too cold. As has been intimated before, the chief difficulty in Minnesota in the establishment of the beet-sugar industry is not in securing a proper growing season, but in having a sufficient time to properly harvest and protect the beets. The sudden, and often early, advent of winter in the northern and western portions of the State will be the cause of difficulties of a serious nature in the harvesting and siloing of the beets. These are factors which intending investors will do well to carefully consider. In general, the conditions of growth are so favorable as to warrant the careful study of the soils of the State by the agricultural experiment station with a view to selecting those localities where the conditions of culture are most favorable. In a State of such vast area it is far better to determine those restricted sections where the conditions are most favorable rather than try to establish the industry indiscriminately in every portion of the State.

In cooperation with the Department of Agriculture, the agricultural experiment station of Minnesota conducted an extensive series of culture experiments in various parts of the State. The general results of the experiments are indicated in the report of the chemist of the station, which follows.

EXPERIMENTS CONDUCTED BY THE AGRICULTURAL EXPERIMENT STATION OF MINNESOTA.

The seed from which the beets were grown was obtained from a variety of sources. Some procured seed from the stock which the legislature directed the State treasurer to purchase. About 100 pounds of seed were obtained from the United States Department of Agriculture and distributed by the experiment station. Some seed was obtained direct from Germany, while a few obtained seed from seed dealers and other sources. As a rule, the seed was of good quality. Only a few instances of poor seed were reported. There was but little difference as to the quality of the beets produced by the seed furnished by the State and by the Department of Agriculture. At the experiment station the average of four plots of Kleinwanzlebener beets grown from State seed showed 17.5 per cent sugar, with a purity coefficient of 86.7, while the average of four plots of Kleinwanzlebener beets grown from United States Department of Agriculture seed gave 17.4 per cent sugar and a purity coefficient of 87.8.

The past season has not been one particularly favorable to the production of the highest quality of beets. It has been the most unfavorable season in nine years. As a whole, however, the results have been satisfactory, and I consider them of unusual value, because they indicate the quality of the beets which are produced in an unfavorable rather than a favorable season.

At the experiment station the average of those plots which were grown under normal conditions gave a sugar content of 17.4 per cent and a purity coefficient of 87.3.

There is one factor in our favor which I think has been overlooked in considering desirable locations for sugar-beet factories, and that is, we have never lost a sugar-beet crop from hot, dry winds, which occasionally occur in some of the prairie States.

About three hundred samples of beets have been tested during the season. In many cases the results were lower than they would have been if the beets had been properly cultivated. In one of the tables the results are given of some of the beets which have been grown under abnormal conditions. In one case twenty-five minutes' time was spent on a quarter acre of beets, while in another case the seeds were planted five inches. These results, while they possess no value as indicating the quality of sugar beets which may be produced in a locality, are nevertheless valuable, because they emphasize the importance of the right kind of cultivation for sugar-beet production.

Sugar beets grown at the Minnesota Experiment Station.

	No. plot.	No. tests.	Sugar.	Purity coefficient.	Average weight.
			Per cent.	*Per cent.*	*Ounces.*
Highest results: Rows 18 inches apart and beets 4 inches in row	......	......	18.5	92.5	12.8
Lowest results: Rows 30 inches apart and beets 10 inches in row	......	......	14.2	78.0	18.4
Average of rows:					
24 and 30 inches apart and beets 4 to 6 inches in row	8	16	16.0	86.1	15.1
24 and 30 inches apart and beets 6 to 10 inches in row	8	16	15.8	85.5	14.9
14 and 18 inches apart and beets 8 and 10 inches in row	8	16	15.9	85.4	14.1
14 and 18 inches apart and beets 4 and 6 inches in row	8	16	17.4	87.3	11.6

The cultivation of the beets was under the supervision of the Agricultural Division. The analyses were all made by the chemist of the station.

The analytical data obtained are summarized from the details of the chemist's report in the following table:

Total number of analyses reported	143
Average weight of the beets (ounces)	17
Average per cent of sugar in the juice	13.8
Average coefficient of purity	81.8

The classification of results is made in several portions, namely, analyses of miscellaneous samples from the State at large and analyses of special samples from definite localities. In the analyses of miscellaneous beets collected from different parts of the State, with the exception of those specially mentioned below, thirty-four samples were examined. The mean weight of the beet is not given in this table of analyses. The mean percentage of sugar in the juice is 14.25 and the mean purity coefficient 82.

Sixteen samples grown at Mankato, Minn., showed an average weight of 21.9 ounces, a mean percentage of sugar in the juice of 12.8, and a purity coefficient of 80.2.

Ten samples grown at Winton and Stockton had an average weight of 17.1 ounces, contained 13.7 per cent of sugar in the juice, and had a purity coefficient of 81.9.

Eighty-three samples grown at Albert Lea had an average weight of 16.6 ounces, contained 13.8 per cent of sugar in the juice, and had a purity coefficient of 82.1.

In general, it will be observed that the results obtained on the samples sent directly to the station were better than those secured at the laboratory in Washington. Upon the whole, the results of the work done at the experiment station are eminently satisfactory, especially as they were accompanied with the statement of the director that the conditions were the most unfavorable, for the development of a crop of sugar beets, which had been known in the State since the commencement of the experiments in this direction, in 1888.

The results of the analyses of the beets grown at the station are extremely satisfactory. The average weight of the beet, to be sure, is somewhat low, but this doubtless was due to an unfavorable growing season. The mean percentage of sugar in the beets grown in different plots is exceptionally fine, and the coefficient of purity in one instance is higher than could reasonably be expected with the best kind of culture. Only in one of the plots cultivated on the station are the results unsatisfactory, and in this case it is the coefficient of purity especially which has fallen below the standard.

MISSOURI.

Very extensive experiments were made in Missouri, about 4,000 samples of seed having been distributed, and over 600 returns made. There were sent directly to the Department of Agriculture 324 samples, detailed analyses of which are found in the preceding tables. The average weight of the samples received was 20 ounces. The mean percentage of sugar in the beet was 11.7 and the mean purity 73.5. Many individual samples from the State show excellent qualities, but reliable judgment, as intimated before, can only be based upon large numbers of analyses. Among the counties furnishing beets of high quality may be mentioned Barton, in the southwestern part of the State. Three samples were received from this county, all of them of rather large size and fine content of sugar, the mean size being 27 ounces, the mean content of sugar in the beet 15.3 per cent; only the purity in all cases was a little low, the mean being 77.3. Benton County, in the center of the State, also showed good results, five samples having an average weight of 16 ounces, an average sugar content of 15.5 per cent, and an average purity of 77.1. The best single sample received was from Pulaski County, in the center of the State, the percentage of sugar being 18.3, the purity 86.1; but the weight was low, namely, only 12 ounces.

Two hundred and ninety-nine samples of beets were sent directly to the agricultural experiment station of Missouri and analyzed in the laboratory of that station. The mean results, by counties, obtained on analysis are given in the following table:

Summary of analyses of beets grown in Missouri.

[From Report of Missouri Experiment Station.]

County.	Number of samples.	Average weight.	Sucrose in juice.	Coefficient of purity.	County.	Number of samples.	Average weight.	Sucrose in juice.	Coefficient of purity.
		Ozs.	*Per ct.*				*Ozs.*	*Per ct.*	
Adair	2	29	14.31	82.89	Livingston	1	12	9.75	70.34
Andrew	1	22	12.16	76.76	McDonald	5	19	13.83	80.05
Audrain	1	32	7.10	56.66	Macon	1	14	14.11	70.89
Barry	4	24	12.85	73.96	Madison	2	20	13.07	71.85
Barton	1	41	16.97	81.62	Maries	1	28	12.95	78.92
Bates	1	22	11.56	76.82	Marion	4	32	9.76	69.32
Benton	2	16	18.19	86.36	Mercer	1	44	13.51	80.22
Boone	2	29	8.19	63.78	Mississippi	8	24	10.57	75.00
Buchanan	4	34	12.20	81.88	Monroe	2	11	7.71	57.57
Butler	1	8	6.47	58.23	Montgomery	5	21	12.62	78.11
Caldwell	6	35	12.99	80.16	New Madrid	2	20	12.30	79.03
Callaway	3	33	12.45	76.45	Nodaway	4	42	11.66	72.61
Carroll	2	28	11.08	75.03	Oregon	1	20	8.37	67.12
Cass	3	22	16.36	84.75	Ozark	1	6	13.81	77.15
Cedar	1	7	11.08	78.86	Perry	1	16	14.06	74.86
Chariton	4	16	12.35	74.24	Pettis	8	24	10.05	65.67
Christian	3	32	11.14	67.86	Phelps	4	13	11.31	75.56
Clark	1	54	12.80	77.76	Platte	4	27	12.11	74.74
Clay	1	36	8.87	67.16	Pike (average)	63	21	10.14	75.55
Cooper	4	19	8.43	61.69	First harvest	38	21	10.94	76.81
Crawford	3	20	11.95	81.27	Second harvest	25	21	9.34	74.30
Dade	2	30	10.56	67.95	Randolph	2	16	14.30	80.17
Dallas	2	16	14.06	74.95	Ray	6	44	10.95	72.40
Dekalb	2	46	10.11	70.40	Saline	3	21	13.74	76.39
Dent	1	10	14.51	72.66	Schuyler	3	25	15.74	82.30
Douglas	2	4	15.19	88.68	Scotland	2	20	15.51	79.46
Franklin	3	30	9.81	70.81	Scott	3	26	9.70	66.43
Gasconade	2	19	10.88	68.60	Shannon	3	12	11.94	76.10
Gentry	7	31	12.68	75.42	Shelby	1	8	7.87	76.26
Greene	1	20	12.27	77.17	St. Charles	5	58	11.21	78.36
Grundy	1	18	12.16	71.11	St. Clair	1	6	21.02	92.19
Harrison	1	6	18.45	....	St. François	2	22	9.68	61.99
Henry	3	25	11.05	66.76	St. Louis	6	27	13.53	82.80
Hickory	1	24	11.88	76.66	Stoddard	1	16	14.79	74.19
Holt	4	29	10.26	73.29	Sullivan	2	26	16.08	85.92
Howell	2	28	13.10	78.18	Taney	3	15	13.08	74.95
Iron	2	13	13.11	79.76	Texas	2	13	14.33	78.47
Jackson	4	36	12.14	79.28	Vernon	7	36	13.17	80.30
Jasper	6	27	11.04	72.57	Warren	2	36	8.07	61.48
Jefferson	3	17	10.71	66.73	Washington	1	28	10.71	73.71
Johnson	5	22	11.90	72.54	Wayne	1	22	13.08	....
Knox	1	46	12.81	74.87	Webster	1	14	13.12	80.58
Laclede	5	19	12.36	68.62	Worth	1	34	11.35	73.13
Lafayette	4	25	11.45	74.08	Wright	4	13	14.01	83.24
Lawrence	1	24	12.12	78.06					
Lewis	2	25	15.60	82.27	Total and mean	301	28	11.1	74.9
Lincoln	1	42	7.94	57.18					
Linn	5	28	12.28	72.21					

Of the whole number of samples, the percentage of those containing 13 per cent or more of sugar in the beet was 24; the percentage of these beets with a sugar content of 13 per cent or over having a purity coefficient of 80 or over was 83; the percentage of the number of beets containing 13 per cent of sugar which had a purity coefficient of 80 or over and weighing 16 ounces or over was 68.

The average percentage of sugar in the beet for the whole number of samples examined at the station was 11.1. The average coefficient of purity 74.9, and the average weight in ounces 25. A tabular comparison of the mean results obtained by the Missouri station and in the laboratory of the Department will be interesting:

	Total number of samples.	Average weight.	Sugar in juice.	Purity coefficient.
		Ounces.	*Per cent.*	
United States Department of Agriculture	324	20	11.7	73.5
Agricultural experiment station of Missouri	201	28	11.1	74.9

As will be seen above, there is a remarkable agreement between the mean results obtained in the two laboratories. The average size of the samples received at Washington was smaller than that of the beets analyzed at the agricultural experiment station of Missouri, and this is doubtless the cause of the slightly increased mean percentage of sugar obtained in the laboratory of the Department of Agriculture. A general study of the results obtained leads to the inevitable conclusion that Missouri is not very favorably situated for producing beets of the highest quality. It is possible to secure, in some instances, results which are exceptionally favorable, but that such results could be secured continuously, and from season to season, is not probable. The data show that the whole State of Missouri belongs in the same category, in respect of growing rich sugar beets, as the southern parts of the States of Ohio, Indiana, and Illinois. Even the northern counties of Missouri are too far south to give the best results. It is evident, however, in so far as yield is concerned, that Missouri is probably the equal of any State in the Union for growing beets of fine size and large tonnage per acre. Unless exceptional conditions favorable to manufacture are found in the State, it is not probable that the sugar-beet industry will gain a foothold for some time in competition with the more favorable localities farther north and east.

MONTANA.

Only four samples were received from the State of Montana at the laboratory of the Department of Agriculture. The average weight of the samples was 20 ounces, the mean percentage of sugar in the beet 14.4, and the mean purity coefficient of 77.8.

Analyses were also made by the agricultural experiment station of Montana. Fifteen analyses were made of samples grown on the grounds of the station. The average weight of the samples was 14.8 ounces, the mean percentage of sugar in the beet 16.2, and the mean coefficient of purity of the juice 81.9. Thirty samples grown in the Gallatin Valley had a mean weight of 22 ounces, a mean content of sugar in the beet of 13.7 per cent, and a mean coefficient of purity of 76.4. Eight samples grown at Livingston had an average weight of 24.7 ounces, with a mean sugar content of 13.8 per cent in the beet, and a coefficient of purity of 74.3. Nine samples from Kalispell had a mean weight of 32 ounces, a mean content of 13. 5 per cent of sugar in the beet, and a mean coefficient of purity of 76.2. Four samples of beets from Missoula had an average weight of 32 ounces, a mean percentage of sugar in the beet of 12, and a mean coefficient of purity of 73.6. Four samples of miscellaneous origin had an average weight of 23 ounces, an average sugar content in the beet of 12.7 per cent, and a coefficient of purity of 74. The whole number of samples analyzed by the agricultural experiment station of Montana was 70, with a mean weight of 23 ounces, a mean content of sugar in the beet of 14.7 per cent, and a mean coefficient of purity of 77.

The results obtained at the experiment station show what can be done by careful culture, and indicate that Montana, under proper conditions, is capable of producing a fairly good sugar beet. The data in general are sufficiently encouraging to warrant the agricultural experiment station of the State in making a more thorough and careful agricultural survey of the possibilities of beet production.

NEBRASKA.

Thirteen samples grown in Nebraska were received at the Department of Agriculture for analysis. The mean weight of the samples received was 29 ounces, the mean percentage of sugar in the beet 12.9, and the mean purity coefficient 76.9. The studies which have been made in Nebraska have been so thorough in previous years that it would not be advisable to make any deductions from so small a number of samples as was analyzed. In connection with the work done at the Department, the following report of the chemist of the agricultural experiment station of Nebraska may be considered:

RESULTS OF EXPERIMENTS IN NEBRASKA.

We distributed seed to 433 persons. Of these 158 responded, either by sending beets or written communication, or both. Of the 158, 106 returned samples of beets for analysis; 52 reported failure to secure crop. Of the 52 reporting failures, 14 said that the seed failed to germinate; 14 ascribed failure to dry weather; 24 gave various reasons for failure, 13 stating that the crop was destroyed by grasshoppers; 4 lost their crop by reason of stock incursions, and 7 through general neglect.

Putting these figures in the form of percentages: 36.4 per cent of those receiving seed responded in some way; 67 per cent of those who reported to us sent beets for analysis; 26.9 per cent of failures were attributed to dry weather; 26.9 per cent of failures were attributed to poor seed; 25 per cent of failures were caused by grasshoppers; 7.7 per cent of failures were caused by cattle; 13.4 per cent of failures were caused by general neglect.

The results of analyses showed an average of 12.34 per cent of sugar in the juice with a purity coefficient of 75. The highest per cent of sugar in juice was 16.8 with a purity of 78.5. The lowest was 4.6 per cent with a purity coefficient of 45.

Beet seed was sent into sixty-seven counties and beets were received from thirty-six counties.

The average results obtained agree very closely with those secured in the laboratory of the Department of Agriculture.

So long a time has elapsed since sugar-beet growing was commenced in Nebraska on a large scale that it is possible to form some idea of the adaptability of that State for beet growing. The soils of Nebraska are mostly very fertile, with a fairly level surface, and are well suited in this respect to beet culture. The climatic conditions, as will be seen by consulting the map, are somewhat variable, and the rainfall in parts of the State is scant and in all parts of it very uncertain in respect of distribution. Periods of extremely wet weather are apt to alternate with long droughts. Hot winds may be expected over many parts of the State during the period of most rapid growth, and these winds are extremely injurious to all kinds of vegetation. The winters are apt to come on early and with severity, rendering the harvesting season somewhat precarious. There is no doubt of the fact that good beets can be grown under favorable conditions in Nebraska, but the uncertainties of the season are such as to indicate that there will not be a very rapid expansion of the industry in that State until more favorable areas have been thoroughly exploited. For details in regard to Nebraska the reports of the agricultural experiment station of Nebraska, at Lincoln, may be consulted. For about eight years this station has been engaged in the study of this question, and has published numerous and valuable bulletins, many of which can still be obtained by applying to the director of the station.

NEVADA.

A large portion of the State of Nevada, in fact the whole of the northern and western parts, lies within the thermal area suitable to beet culture. Twenty-one samples of beets were received at the Department of Agriculture from Nevada, the average weight of which was 25 ounces, the average content of sugar in the beet 16.6 per cent, and the average coefficient of purity 81.1. These samples all came from the parts of the State lying within the favorable thermal area. The agricultural experiment station of Nevada, at Reno, also made an investigation of the possibilities of growing beets in that State, and has submitted a report on the subject. In all, twenty-two samples were received at Reno for analysis, the average weight of which was 25 ounces, and the average content of sugar 16.9 per cent, the purity not being given. These data show a remarkable agreement with those obtained by the Department of Agriculture. The beets were grown entirely under irrigation. Some of them, however, received only one irrigation and others as high as five.

The results obtained at the station itself were in the highest degree satisfactory. The total number of samples grown and analyzed at the station was ten, the mean weight of the beets was 19 ounces, and the mean percentage of sugar 18.9, purity coefficient not given.

Mr. Stubbs, the director of the station, in submitting his report, states that he distributed 90 pounds of the seed received from the Department to thirty farmers residing in fifteen counties. Only five of the thirty farmers sent samples for analysis. One reported failure from stock breaking into the field and destroying the crop; one, failure from lack of water, and one stated that the samples of seeds sent him did not arrive. Mr. John Harrison reports that there are 20,000 acres of land in a single body such as he used for growing his beets.

All the samples sent to the Department of Agriclutnre by Mr. Harrison, ten in number, were from Humboldt County; the average weight of the samples was 21 ounces, the mean content of sugar in the beets 18.8 per cent, and the mean coefficient of purity 83.1. It is evident that, if such beets as these can be grown in that locality, the 20,000 acres of land suitable to beet culture would suffice to maintain a large factory, which must of necessity prove eminently successful if fuel, limestone, and water can be had in sufficient abundance and sufficiently cheap to operate it. The cultural results in Nevada are of the highest significance. This State, which is devoted chiefly to mining, has very small agricultural interests, but if a few areas capable of irrigation, like that at Lovelocks, in Humboldt County, can be found, Nevada should become a beet producing State. The establishment of this agricultural industry could not fail to be of immense benefit to the Commonwealth. There is no other State in which the reports are more favorable, although it may be said that the number of samples is not sufficiently large to carry absolute conviction. Nevertheless, the uniform excellence of the samples can not be the result of accident, but must have been due to the favorable influences of soil and climate. The agricultural experiment station of this State will do well to make a more careful survey, and especially to map out the localities where the contour of the State is suitable to beet culture and where water can be obtained.

NEW JERSEY.

As has been before stated, New Jersey is traversed from the south toward the north by the mean isotherm of 71° for the three summer months. A portion of it is therefore within the theoretical thermal belt for beet growing. In general, it may be said, however, that the temperature will be found a little too warm to secure the best results. On the other hand, the soil of New Jersey is of a sandy nature, suited to the growth of a beet with a high purity.

The data which have been collected during the season from New Jersey are encouraging. The whole number of samples received from the State was 31, the average weight 16 ounces, the mean content of sugar in the beet 14.2 per cent, and the coefficient of purity 81.4. Essex and Mercer counties each furnished seven samples; the results in Essex County were fairly good, but in Mercer County were poor. Ocean

County furnished eight samples, with a high average percentage of sugar and purity coefficient, but with a weight only half the normal.

No investigations were made by the experiment station of New Jersey, but Mr. James B. Vredenburgh, of Jersey City, conducted some very careful experiments at Freehold, in Monmouth County. The following report of Mr. Vredenburgh is interesting and contains valuable data.

RESULTS OF EXPERIMENTS IN NEW JERSEY.

May 20, 1897.—I had one-quarter acre clover sod plowed and prepared for planting.

May 22.—I had planted four kinds of beet seed, viz, a strip of 111 by 2 feet 9 inches or seven one-thousandths of an acre in imported Vilmorin.

A similar strip in imported Kleinwanzlebener; a similar strip in Government seed, and the balance of the quarter acre in cattle beets.

I fertilized the whole plot equally with 300 pounds of phosphate. I weeded the beets twice, cultivated them five times, and gathered them November 1.

I had one of each kind analyzed each week, commencing August 3, by an expert chemist, the result of which I herewith inclose:

Varieties.	Weight.	
	When gathered.	Without tops.
	Pounds.	*Pounds.*
The Vilmorin	258	239
The Government	279	258
The Kleinwanzlebener	236	220

The Vilmorin, therefore, produced at the rate of 17½ tons to the acre, without tops; the Government, 18 tons to the acre without tops; Kleinwanzlebener, 15 tons to the acre without tops.

It will be seen that by far the best result came from the Vilmorin, the purity of the juice in the analysis of November 1 being 88.20.

This latter result was from an average of three beets, one small, one middle size, and one large.

The cost of the labor, fertilizer, etc., on the one-quarter acre was about $15.

Results on farm at Freehold, Monmouth County.

Date.	Marked.	Weight of the beet.		Percentage of sugar.		Purity coefficient.
		With top on.	With top cut off.	In the beet.	In the juice.	
1897.		*Pounds.*	*Pounds.*			
Aug. 30	No mark	1.171	1.088	10.45	11.30	80.14
30	do	1.384	1.161	11.15	12.50	83.30
Sept. 8	do	1.481	1.168	11.75	12.55	79.40
8	do	1.251	1.000	11.85	....	....
15	Government	2.093	1.545	9.80	10.60	80.60
15	Kleinwanzlebener	1.704	1.329	11.40	12.00	83.90
15	Vilmorin	1.724	1.311	12.40	13.10	84.50
20	No mark (Jack)	0.587	0.505	14.30	15.60	83.40
27	Government	4.391	2.923	10.40	11.25	81.50
27	Kleinwanzlebener	4.491	3.000	10.10	10.35	77.24
27	Vilmorin	4.292	3.058	9.90	10.55	78.47
Oct. 4	Government	2.097	1.700	12.40	13.25	84.30
4	Kleinwanzlebener	1.633	1.225	12.00	13.10	82.40
4	Vilmorin	1.876	1.479	13.80	14.10	86.10
14	Government	1.662	1.474	11.50	12.75	80.20
14	Kleinwanzlebener	2.234	1.770	12.30	12.75	81.70
14	Vilmorin	1.706	1.474	14.20	15.65	84.10
20	Government	1.583	1.378	13.50	14.50	82.00
20	Kleinwanzlebener	2.415	2.087	11.90	12.70	81.90
20	Vilmorin	2.150	1.715	14.30	14.95	83.50
Nov. 1	Government	2.313	1.757	12.40	13.50	78.00
1	Kleinwanzlebener	1.380	1.000	13.10	13.80	83.10
1	Vilmorin	1.270	0.958	14.30	15.35	88.20

Excluding the analyses made before the 20th of September, which would be anterior to the manufacturing season, and including all of those made after that date, we find that the sixteen samples analyzed had an average weight of 27 ounces, a mean content of sugar of 12.5 per cent, and a mean purity of 82.3. These data, obtained by Mr. Vredenburgh, in conjunction with those secured from the analyses of the samples forwarded to Washington, indicate the possibilities of successfully establishing the industry in the State on the lands which are particularly suited thereto. As before stated, however, the danger from a slightly too high temperature must be expected, and while good beets, capable of yielding high percentages of sugar, and with high purities, may be grown in New Jersey, it is scarcely probable that they will reach as high a grade as those grown farther north.

NEW MEXICO.

Only three samples grown in New Mexico were received at this laboratory for analysis. These were all grown in Mora County by the La Cueva Ranch Company. The average size of these samples was small, but the content of sugar and the coefficient of purity of the juice were high. In connection with this work the report of the director of the agricultural experiment station will be found of interest.

RESULTS OF EXPERIMENTS IN NEW MEXICO.

TABLE 1.—*Analyses in the chemical laboratory of the New Mexico Experiment Station prior to October 25, 1897.*

Locality.	Number of samples analyzed.	Average weight of beets.	Average per cent sugar in the juice.
New Mexico Agricultural Experiment Station, Mesilla Park:		*Pounds.*	
Harvested Sept. 15	31	1.21	11.02
Harvested Oct. 14	31	1.53	12.47
Blue Water:			
Harvested Sept. 8	4	1.38	10.50
Harvested Sept. 30	4	1.63	12.70
Albuquerque	3	1.73	13.16
Santa Fe	7	1.06	14.10
Cerro	3	1.04	17.03
Dorsey	1	1.60	12.60
Chapham	1	1.60	15.10
Tularosa	2	1.98	11.20
Anthony	1	1.18	11.50
Maxwell City	3	2.77	14.15
Hatch	1	2.35	11.50
Socorro	1	.48	15.50
Lordsburg	1	.55	16.20
Blossburg	1	3.55	10.80
Aztec Subexperiment Station	1	1.85	14.60
Averages, etc	96	1.61	13.18

TABLE 2.—*Analyses in the chemical laboratory of the New Mexico Experiment Station between October 25 and November 15, 1897.*

Locality.	County.	Number of samples analyzed.	Average weight.	Average per cent sugar in the juice.
			Pounds.	
Aztec Subexperiment Station	San Juan	5	1.5	16.8
Farmington	do	6	1.9	17.6
Jewett	do	1	1.9	13.5
Blue Water	Valencia	4	3.5	10.6
Perea	Bernalillo	2	2.7	12.5
Las Vegas	San Miguel	1	2.8	13.5
East Lasvegas	do	1	3.2	16.1
Pine Spring	Lincoln	1	1.5	13.5
Raton	Colfax	2	2.1	13.1
Maxwell City	do	1	1.7	15.3
Dorsey	do	1	1.1	15.4
Wagonmound	do	1	1.6	13.9
Hatch	Dona Ana	1	1.7	16.5
Santa Fe	Santa Fe	5	1.0	15.9
Hobart	do	1	1.9	14.9
Lacueva	Mora	6	1.1	17.6
Cerro	Taos	1	1.5	18.6
Averages, etc		40	1.7	15.3

TABLE 3.—*Analyses in the chemical laboratory of the New Mexico Experiment Station between November 15 and December 20, 1897.*

Locality.	County.	Number of samples analyzed.	Average weight.	Average per cent sugar in the juice.
New Mexico Agricultural Experiment Station, Mesilla Park.			*Pounds.*	
Harvected Nov. 16	Dona Ana	31	1.7	13.9
Harvested Dec. 15		27	1.6	13.9
Sample came in not marked		1	1.5	17.4
Watrous	Mora	1	.8	12.0
Lacueva	do	2	1.1	15.6
Los Lunas	Valencia	1	2.5	14.5
Blue Water	do	4	1.2	13.8
Roswell	Chavez	3	1.7	13.8
Hagerman	Eddy	3	1.2	13.5
Santa Fe	Santa Fe	3	.8	18.0
Espanola	do	5	1.6	14.1
Jewett	San Juan	1	2.2	13.0
Las Vegas Subexperiment Station	San Miguel	1	1.6	17.6
Averages, etc		83	1.6	14.1

Our work is still in an incomplete condition, as we have not had time to estimate the coefficient of purity and consider some other points in connection with these analyses. I beg to call your attention to the fact that nearly all of the beets analyzed here were grown by farmers who had had no previous experience in growing beets, and whose habits of farming are extremely loose. We can say definitely that if these beets had been grown under such conditions as would be expected to obtain upon a well-regulated farm, the results would have been very much more satisfactory. We know that the conditions under which the most of the samples grew on the station farm here were not of the most satisfactory kind, as we are trying experiments on time of planting, time of harvesting, variety testing, deep and shallow plowing, different modes of irrigation, etc. It is now established beyond a doubt that New Mexico can grow large crops of sugar beets, containing a very high percentage of sugar.

Located at Eddy, in the southeastern part of the Territory, there is already established a sugar-beet factory, doing a successful and profitable business.

In the northern portions of the Territory coal is comparatively cheap, and the completion of a railroad now in process of building will very materially cheapen coal in the southern part of the Territory.

Limestone seems to be scattered pretty well throughout the Territory, and while we have not had time to go fully into this subject, the few analyses that we have made indicate that the Territory affords limestone of a very good grade. We have just taken a survey of the limestone and waters of the sugar-beet districts. The question of water is engaging our attention, too; and we believe that water of fairly good quality can be secured.

There is a lively interest taken in sugar-beet work in all parts of the Territory, and from the tables herewith inclosed the most favorable locations can easily be selected. Particular attention should be called to the Rio Grande Valley, especially the northern portion, and the Animas Valley. This latter has an extensive and abundant supply of very good water, but at present no railroad. This valley seems to be a very promising section for the production of sugar beets. See Aztec and Farmington in the tables.

The soils of the Territory contain, I think, about the average amount of nitrogen and phosphoric acid and about the usual amount of potash. They have a decided advantage over the soils in the rainfall districts, because the fertility is largely kept up by the plant food contained in the irrigating water, and nearly all that once gets on the soil remains, as very little, indeed, is lost by leaching and drainage.

We expect to publish a bulletin about the 1st of February, giving our results in detail.

The analyses which were made by the chemist of the agricultural experiment station of the samples received by him are classified in accordance with the time at which they were made. Ninety-six analyses made prior to October 25 showed an average weight of the samples of 26 ounces, with an average content of sugar in the beet of 12.5 per cent. The purity coefficient of the juice is not given.

Forty samples analyzed between the 25th of October and the 15th of November had an average weight of 27 ounces, with an average content of sugar in the beet of 14.5 per cent, the purity coefficient not being stated.

Eighty-three samples analyzed between November 15 and December 20 had an average weight of 26 ounces, and an average content of sugar in the beet of 13.4 per cent. The purity was not given.

It is evident that there are many localities in New Mexico where the conditions of temperature are most favorable to the growth of beets. There are also large areas of fairly level land which are capable of irrigation. Wherever the temperature of these regions is sufficiently low to permit the proper development of the beet, and where sufficient water for irrigation can be secured, there is reason to believe that the industry may be established and prove to be fairly profitable. While the summer days in New Mexico are not so long by an hour or more as in the regions farther north, the amount of sunshine which the growing beet will receive is practically as great as in more northern localities, because of the comparative absence of cloudy and rainy days. The remarks which have already been made in regard to the growth of beets on irrigated areas apply to New Mexico. This is a subject which demands the most careful scientific study, and the work which is now doing by the agricultural experiment station of the Territory is certain to bear excellent fruits in the near future. New Mexico is provided with a beet-sugar factory in the extreme southwestern portion of the Territory, and thus a practical demonstration of the possibilities of beet growing can be made. It is difficult to secure definite data from this factory, but from the meager reports received it is believed that the season's work has not been so successful as had been expected from the results obtained during the preceding year. Accounts have been received of a mold or fungus attacking the beets, and it is also evident that the true principles of irrigation have not yet been thoroughly worked out. There should not, however, be anything discouraging in accidents of this kind, as the conditions, upon the whole, are such as to warrant the expectation of final success.

NEW YORK.

On January 16, 1894, in addressing the New York Farmers Club on the subject of beet sugar, I used the following words:

> The plateaus of the great West subject to irrigation are especially suited to the production of sugar beets. The same is true of the lands of certain portions of Nebraska and Dakota, of Iowa, Minnesota, and Wisconsin, of northern Illinois, Indiana, Ohio, and New York. Recently, in passing over the valley of the Genesee River, I was particularly struck with the quality of the soil and its suitability to beet culture. The valley of the Genesee is only a type of hundreds of thousands of acres in New York which could be profitably devoted to beet culture.

At that time practically no experiments had been made to determine the suitability of the soil and climate of New York for producing high-grade beets. In fact, not until the last year has any systematic attempt been made to ascertain the capabilities mentioned above. In the spring of 1896, in conversation with a committee of the board of trustees of the agricultural experiment station at Geneva, I urged upon them the desirability of studying the capabilities of New York for beet production. In 1897 the Department of Agriculture, in cooperation with the experiment stations at Geneva and Ithaca, conducted a series of investigations throughout the State of New York, which has given data of extraordinary interest and importance.

The climatic conditions, as respects temperature and rainfall, affecting the State of New York have already been discussed. It has been seen that there are two areas in which the thermal conditions are particularly favorable, separated by a large area where the mean summer temperature is less than 69°. It has already been pointed out, however, that a lower temperature than 69° is still highly favorable to the production of beets of superior excellence if coupled with conditions which permit their maturity and harvest in time to avoid the severe frosts of winter. These conditions exist in a marked degree throughout the whole of the region in New York lying between the Hudson River on the east and the Great Lakes on the west, excluding the extreme northern portion, where the altitude and mountainous character of the country preclude the possibilities of beet culture. The whole of the area named, therefore, where the contour is favorable and the character of the soil suitable may be regarded as a prospective area of sugar-beet culture.

SAMPLES RECEIVED AT THE DEPARTMENT OF AGRICULTURE.

From the seed distributed to farmers in different parts of the State, 225 samples of beets were received at the Department of Agriculture for analysis. The mean weight of these samples was 21 ounces, the mean percentage of sugar in the beet 15, and the mean coefficient of purity 82.4. Every county in the State reporting results showed favorable data. The counties having the largest number of samples of course gave data which are the most instructive.

Cattaraugus County supplied 15 samples, with a mean weight of 18 ounces, a mean percentage of sugar in the beet of 15.1, and a mean coefficient of purity of 81.9.

Chautauqua County furnished 45 samples, with a mean weight of 21 ounces, a mean sugar content in the beet of 16.6 per cent, and a mean coefficient of purity of 82.7.

Erie County sent 37 samples, having a mean weight of 19 ounces, a mean content of sugar of 15.9 per cent in the beet, and a mean coefficient of purity of 83.9.

Oneida County was the source of 22 samples, with a mean weight of 14 ounces, a mean sugar content of 13.6 per cent, and a mean coefficient of purity of 81.8.

Ontario County furnished 22 samples, having a mean weight of 17 ounces, a mean content of sugar in the beets of 15 per cent, and a mean coefficient of purity of 83.4.

Yates County supplied 15 samples, having a mean weight of 23 ounces, a mean sugar content of 12.7, and a mean coefficient of purity of 79.6.

The uniformly good properties of so large a percentage of samples collected in the promiscuous way made necessary by the method of the experiments show beyond question the favorable auspices under which they must have been grown.

In addition to the special plot work on high-grade beets which was conducted under the supervision of the Geneva station, cooperative work by the Department of Agriculture, in conjunction with the farmers of the State, was also carried on. From the whole number of packages of seed distributed by the station, 135 samples of beets were received for analysis, and the results obtained, without distinction of locality, are shown in the following report of Director Jordan:

RESULTS OF EXPERIMENTS IN NEW YORK.

The number of samples reported is 135, which came from a sufficient number of points in the State to make them fairly representative of the conditions prevailing.

I make no report to you of the production, because in most instances, whenever the tonnage was reported, the figures appeared to us to be unreliable because of the methods used in reaching them.

Kleinwanzlebener.

Beets containing sugar.	Number of samples.	Average per cent sugar in beet.	Coefficient of purity.	Average weight of one beet.
Per cent.				*Ounces.*
11-12	4	12	76.5	20
12-13	11	13	75.4	18
13-14	10	13.8	80	14
14-15	11	14.7	80.3	17
15-16	15	15.8	84.3	14
16-17	11	16.5	85.3	16
17-18	13	17.6	85.2	14
18-19	3	18.5	85.9	13

Vilmorin Improved.

Number of samples.	Average per cent sugar in beet.	Coefficient of purity.	Average weight of one beet.
			Ounces.
3	11.7	75	16
5	12.8	76.7	24
9	13.8	82.4	19
8	14.8	83	16
17	15.6	82	16
9	16.6	87.5	15
6	17.8	85.4	18
2	18.6	83.8	24

My chief anxiety with regard to the development of the sugar-beet industry in New York is that farmers shall not reach unwarranted conclusions concerning the profits of their side of the work. I have no reason to believe that the industry will prove more profitable to our farmers than the production of several crops which we are now growing. I recognize, of course, the benefits of adding to our list of crops another one which will have a ready cash market.

There appears to be a move all over the State for the establishment of factories at desirable centers, and promoters are already in the field who are, as a rule, urging the farmer to invest in beet sugar-factory stock. I am very much afraid that there will be serious misdirection of capital, which will not only cause the farmer to lose money, but seriously disappoint him in regard to the benefits from growing sugar beets. My judgment is that the matter should be discussed by those who take the lead in the matter in the most conservative way, and both farmers and business men should be severely cautioned to proceed slowly and only after extended and careful investigation.

A carefully grown crop of sugar beets yielded on the experiment station farm this season at the rate of 16¼ tons per acre, carrying 15.2 per cent sugar in the beet and 16 per cent in the juice. No dependence should, in my judgment, be placed upon the reports of yields of 25 and 30 tons per acre of high-grade beets in this State.

In studying the report of Director Jordan we see that of the Kleinwanzlebener variety only four samples out of the whole number fell below the minimum of 12 per cent of sugar in the beets, and of the Vilmorin variety only three. This is without doubt a remarkable showing of excellence, in so far as the content of sugar is concerned. The caution of Director Jordan to proceed carefully in this matter, and with a due study of the factors, is perfectly in harmony with the tenor of the reports which have been issued by the Department of Agriculture, on the subject of beet sugar, from time to time during the past fifteen years, and is deserving of careful consideration, both by intending investors and farmers. Our reports have constantly dwelt upon the danger of misdirected enthusiasm and failure to study properly all the factors entering into any enterprise connected with the manufacture of sugar.

The agricultural experiment station of Cornell University, at Ithaca, also cooperated with the Department in the experimental work in New York. Four hundred and twenty-five samples were received for analysis at the experiment station at Ithaca. The data obtained on analysis, arranged by counties, are given in the report of Director Roberts. In this report the percentage of sugar in the juice of the beet only is given, the mean being 16.9. Converting this number into terms of the sugar in the beet, the percentage becomes 16.1, which is one point higher than the mean percentage of sugar in the samples from New York analyzed by the Department of Agriculture. The coefficient of purity, 83.5, obtained at the Ithaca station is only a little over one point higher than that secured from the analyses by the Department of Agriculture.

Director Roberts, in his report, estimates that the mean yield per acre obtained in the State of New York was 17 tons, but as his estimate is made upon the returns made by the farmers, many of which are evidently too high, it is not final as a source of deductions in regard to the average yield which may be obtained. It is not at all likely that an average yield of 16 tons per acre could be obtained, even by the best culture.

The counties furnishing the data with the most weight are Broome, Chautauqua, Erie, Genesee, Monroe, Steuben, and Wayne. Chautauqua County, especially, is to be regarded on account of the mean data being based upon 122 separate samples, in which the mean percentage of sugar in the juice was 16.8, and the mean coefficient of purity, 83.5. The next highest number is furnished by Genesee County, where the mean percentage of sugar in the juice from 62 samples is 16.6, and the coefficient of purity, 82.9. Monroe, with 59 samples, showed a mean sugar content in the juice of 17.2 per cent, and a mean coefficient of purity of 83.9. Erie County, with 38 samples, gave a mean content of sugar in the juice of 17.9 per cent, and a mean coefficient of purity of 86.3. Wayne County furnished 27 samples, having a mean content of sugar in the juice of 16.7 per cent, and a mean coefficient of purity of 82.9. Broome County sent 25 samples, containing 16.2 per cent of sugar in the juice, with a coefficient of purity of 81.8; and Steuben County furnished 24 samples, containing 16.2 per cent of sugar in the juice, with a coefficient of purity of 82.6. Following is the report of Prof. Roberts:

The 500 pounds of sugar-beet seed sent us by the Department of Agriculture were distributed to over 300 farmers of the State, with directions as to preparation of the soil, planting, and cultivating. During the growing season, the larger part of the plats was inspected by an officer of this station and observations made as to the general conditions found.

The season was a favorable one, and in nearly all cases the beets made good growth, and that the per cent of sugar was satisfactory will be shown by the table of analyses given later.

It is safe to say that the citizens of New York State, both capitalists and farmers, are thoroughly awakened to the importance of the subject of the manufacture of sugar from beets. During the season one factory has been in successful operation at Rome, N. Y. Other factories are contemplated, and at the present time agents are in France negotiating for machinery to be used in a large factory to be erected the coming season.

Officers of this station attended eight meetings of farmers and capitalists to give information and advice as to the advisability of locating factories in certain sections of the State. Abundance of capital is ready to be invested once the success of the industry is assured. Farmers feel that in the raising of sugar beets a new avenue is open for them, and in most parts of the State favorable for the growth of beets they are heartily favoring the new enterprise.

When the various experimental plats were harvested, agents from this station personally superintended the taking of the samples and the calculations of yield on 178 of the plats. To those farmers whose places we were unable to visit directions were sent as to how the samples should be taken and the yield estimated; so it is believed that this report of results is a fair statement of what can be done in New York State in the way of raising sugar beets.

The necessity now seems to be the education of the farmers in the system of intensive culture necessary for the successful raising of the beets. The farmers appreciate the importance of this instruction, and are eager to learn. It is safe to predict that the manufacture of sugar from beets is to be one of New York's prominent industries in the near future.

The following report is furnished by our chemists, summarizing the results by counties:

Report of sugar-beet experiments in New York, 1897.

County.	Sugar in juice.	Purity coefficient of juice.	Total number of samples analyzed.	County.	Sugar in juice.	Purity coefficient of juice.	Total number of samples analyzed.
	Per cent.				*Per cent.*		
Albany	17.25	86.6	1	**Oneida**	16.16	82.1	4
Broome	16.23	81.8	25	**Onondaga**	17.40	86.6	1
Cattaraugus	16.94	84.5	15	**Orleans**	17.20	86.1	3
Cayuga	17.34	84.3	10	**Oswego**	14.45	76.1	1
Chautauqua	16.83	83.5	122	**Saratoga**	20.25	86.6	1
Erie	17.93	86.3	38	**Schuyler**	16.26	79.7	2
Genesee	16.62	82.9	62	**Seneca**	16.58	83.2	5
Herkimer	13.85	79.2	1	**Steuben**	16.24	82.6	24
Jefferson	16.16	81.0	3	**Tioga**	18.73	82.7	2
Livingston	19.25	85.6	1	**Tompkins**	17.49	83.1	8
Monroe	17.22	83.9	59	**Wayne**	16.74	82.9	27
Montgomery	15.08	79.3	3				
Niagara	17.31	83.4	7	**Average**	16.89	83.5	425

From the foregoing data, the conclusion is inevitable that the State of New York stands among the first in the Union in its capabilities of producing beets with a high content of sugar and a high purity. The meager data at hand also show that a fair tonnage per acre can be secured. It is evident that with proper fertilization and rotation of crops the fertility of the soil can not only be maintained, but even increased, so that it is not unreasonable to expect, under the best conditions of culture, that the mean tonnage per acre produced in the State of New York will be quite equal to that of the best sugar regions of Germany. Judging by the data obtained from a single season alone, there is no sugar-beet producing country of Europe that can compete with the State of New York in the richness of its beets. If a factory, constructed on the best approved modern principles, and with every facility for converting the whole of the sugar into marketable form, could be supplied with such beets as were grown in the State of New York during the season of 1897, it would be capable of placing upon the market 240 pounds of pure granulated sugar for every ton of 2,000 pounds of beets entering into manufacture. When, in addition to these facts, are considered the cheapness of fuel, the abundance of labor, the proximity of markets, and the importance of the dairy industry in its relations to the refuse of the factory as a feed, it is seen that there is no place in the United States which offers more favorable inducements for the development of the industry.

ELEVATION OF REGIONS OF NEW YORK SUITED TO BEET CULTURE.

A contour map of the State of New York, showing the elevations above tide water, is found in the fifth annual report of the meteorological bureau and weather service of the State for 1893. The elevation in the region of the Catskills in some places reaches an altitude of 3,000 feet. Immediately west of this mountainous region, and extending to Binghamton on the south and almost across the State through the south central portion, there is a large area in which the average elevation is 1,000 feet. In the southwestern portion of the State there is a considerable area the elevation of which is 1,500 feet. The region of the Adirondacks and the northeastern portion of the State has various elevations, but as these regions are probably too far north for successful beet culture they do not interest us here. Starting from Albany with an average elevation of 100 feet and following the course of the New York Central Railway, we pass through an area a large portion of which is below 500 feet in elevation. From Rome through Syracuse and as far west as Lyons the average elevation is less than 500 feet, with the exception of small areas. From Lyons to Buffalo the average elevation is above 500 and less than 1,000 feet. Immediately along the shores of Lake Ontario the average elevation is less than 500 feet. Passing to the south near Rochester, along the Genesee Valley, is a considerable area below 500 feet in elevation.

An interesting description of the physical contour of the State is given in the report mentioned above as taken from the work of Prof. Arnold Guyot. This description is as follows:

> The following outline of the orography of New York is substantially as given by Prof. Arnold Guyot. Further details are exhibited by the accompanying relief map.

The mass of the State is a triangular table-land elevated 1,500 or 2,000 feet above the ocean, and may be considered the northeastern extremity of the plateau which, in this latitude, forms the western half of the Appalachian system. The natural limit of this belt toward the west and north is the large depression of Lakes Erie and Ontario, and which continues down the course of the St. Lawrence River to the ocean. In the east the table-land is terminated by the deep valley occupied by Lake Champlain and the Hudson River, while southward the highlands extend without interruption into Pennsylvania. The eastern edge along the Hudson and Champlain valleys is formed by a series of mountain chains more or less isolated from each other, and bearing the highest summits in the State. They are: The Highlands, which cross the Hudson at the limit of the coast region; the Shawangunk and Catskill mountains, on the western bank of the river, and the system of the Adirondacks, covering the territory between the St. Lawrence and Champlain valleys. Within this eastern wall the true mountain chains cease, but the remainder of the plateau is indented by numerous valleys, the bottoms of which are generally several hundred feet below the common level, and which are separated by high ridges. A remarkable feature is the deep transversal cut which forms the valley of the Mohawk and Lake Oneida, opening a channel from the low country of the Lake region to the Hudson valley, and thus dividing the main plateau into the distinct masses of the Appalachian and Adirondack systems.

A subdivision of the central or Appalachian highlands is due to the deep channel of Seneca Lake, extending from the plains bordering Lake Ontario southward to the valley of the Susquehanna. The two sections of the highlands thus separated are here designated as the eastern and western plateaus, the former extending from the central lakes to the Hudson Valley, and the latter westward from the central lakes to the depression of Lake Erie.

NORTH DAKOTA.

Only four samples were received from North Dakota, the average weight of which was 28 ounces, and the mean percentage of sugar in the beet 10.5. On account of the low content of sugar, purity coefficients were not computed.

No report has been received from the director of the North Dakota station in regard to any work which has been carried on by that station. The data of the four samples received are likely to be misleading, as it is evident that North Dakota is capable of producing very much better beets than are indicated by the data in the analytical tables.

NORTH CAROLINA.

By consulting the map it may be seen that there are many localities in North Carolina where the thermal conditions are favorable for the growth of high grade beets. It is doubtful, however, whether upon the summits of the Allegheny Mountains, where these conditions exist, a sufficient area of suitable soil could be secured to warrant the expectation of establishing successfully a beet-sugar industry in that State.

Only seven samples were received from North Carolina by the Department of Agriculture. The mean weight of these samples was 23 ounces, and the mean percentage of sugar in the beet 9.1. On account of the low polarization of the samples, it was not deemed necessary to make a computation of the coefficient of purity.

No analyses were made at the laboratory of the experiment station of North Carolina during the year, although the director of the station has been much interested in the work, and proposes to continue it another season.

OHIO.

Sixty-eight samples of beets grown in Ohio were received at the Department laboratory for analysis. The mean weight of these beets was 22 ounces, the mean content of sugar 13.8 per cent, and the mean coefficient of purity, 79.1. Grouped by belts into northern, central, and southern, the character of the beets grown in Ohio and analyzed at the Department of Agriculture is shown in the following table:

Summary of analyses of beets from Ohio, by belts.

Belts.	Number of samples.	Average weight.	Sugar in beets.	Purity coefficient.
		Ounces.	*Per cent.*	
Northern belt	42	21	14.1	79.9
Central belt	19	23	13.6	78.5
Southern belt	7	26	12.7	75.7

It will be seen from the above that the northern belt of the State produced the best beets, both in content of sugar and purity, and in this respect the data obtained by the Department corroborate in every particular those secured by the Ohio Experiment Station mentioned below. It is evident, from a consideration of the two sets of data, that the northern portion of Ohio offers favorable inducements, both for the culture of the beet from an agricultural point of view and by reason of cheapness of fuel and the facilities of transportation from the manufacturing point of view. It is evident, however, that the central and southern parts of the State, as is the case with Indiana and Illinois, should not be exploited with the purpose of investing money in the beet-sugar industry until the available localities in the northern regions are entirely occupied.

With the cooperation of the Department of Agriculture, the agricultural experiment station of Ohio distributed a large quantity of seed to farmers in that State, and from the seed so distributed 607 samples of beets were forwarded to the station and analyzed. The results of the analyses by counties are given in the following table:

EXPERIMENTS CONDUCTED BY THE OHIO AGRICULTURAL EXPERIMENT STATION.

Summary of results of sugar-beet investigation for Ohio, 1897.

County.	Number of samples analyzed.	Average weight of beets.	Sucrose in juice.	Purity coefficient.	County.	Number of samples analyzed.	Average weight of beets.	Sucrose in juice.	Purity coefficient.
		Grams.	*Per ct.*				*Grams.*	*Per ct.*	
Ashland	4	831	12.7	76.0	Marion	7	555	12.4	77.5
Ashtabula	2	679	14.9	82.8	Medina	6	947	13.9	76.2
Auglaize	9	1,128	14.4	77.0	Mercer	11	1,119	13.2	77.2
Belmont	1	660	16.6	86.9	Miami	12	773	12.6	75.9
Champaign	1	825	13.2	77.6	Montgomery	3	755	11.8	73.5
Clark	11	610	14.1	78.7	Muskingum	5	566	14.4	78.2
Columbiana	1	610	18.4	83.6	Ottawa	13	694	15.7	78.8
Coshocton	4	860	12.0	72.9	Paulding	9	802	15.6	80.0
Crawford	7	1,095	13.8	77.1	Perry	1	127	19.1	80.9
Cuyahoga	4	894	12.9	75.5	Pickaway	1	710	16.5	81.6
Darke	44	864	13.3	76.9	Pike	1	595	14.0	77.8
Defiance	23	851	13.7	77.9	Portage	2	1,554	9.3	a69.7
Delaware	4	559	14.9	79.3	Putnam	19	958	13.1	76.5
Erie	1	1,406	15.0	80.6	Richland	2	496	16.6	83.4
Fairfield	5	599	12.8	74.9	Ross	31	697	13.5	76.6
Fayette	2	620	14.6	78.9	Sandusky	3	812	14.8	79.6
Franklin	5	524	15.3	80.0	Seneca	10	762	14.8	77.5
Fulton	24	1,065	14.1	79.2	Shelby	8	607	14.0	80.0
Geauga	6	694	16.3	84.8	Stark	8	712	15.3	80.8
Greene	11	1,285	9.9	66.8	Summit	28	684	14.7	80.2
Hardin	4	796	12.1	74.2	Tuscarawas	4	865	14.8	79.1
Henry	33	810	15.3	80.9	Union	2	1,077	15.9	80.6
Highland	1	840	13.2	68.4	Van Wert	21	1,064	12.5	73.1
Hocking	1	1,521	7.2	a59.0	Wayne	97	787	13.9	80.7
Holmes	6	680	13.6	81.0	Williams	3	979	16.2	80.2
Huron	1	303	16.0	76.1	Wood	26	777	14.4	78.3
Knox	4	642	15.9	81.9	Wyandot	1	605	15.1	79.8
Lake	5	789	14.9	82.7					
Licking	11	562	11.9	74.9	Southern section	69	892	12.8	75.3
Logan	2	779	12.8	80.0	Middle section	146	924	13.9	78.0
Lorain	1	520	16.0	81.2	Northern section	392	834	14.3	79.4
Lucas	32	889	14.3	78.5					
Madison	5	711	14.3	76.8	Entire State	b607	867	14.0	78.7

a Not included in average of State.
b Some samples were received without name and address of grower.

It will be observed from the above table that the number of samples analyzed was 607. Only 554, however, of these samples figure in the averages for the State, the others having been rejected for computing purposes by reason of certain abnormalties which they presented. The Ohio results are exceedingly encouraging from every point of view, with the exception of purity alone. The average weight of the beets was 867 grams, equivalent to 30.6 ounces. The average per cent of sugar in the expressed juices was 14 per cent, equivalent to 13.3 per cent in the beet, and the average coefficient of purity of the juices was 78.7. The most interesting grouping of the samples is shown at the end of the table, particularly so because in the State of Ohio the most favorable theoretical thermal conditions prevail only in the northern counties. The grouping of the total number of samples into three portions, representing the northern, central, and southern sections of the State, shows in a convincing manner the effect of thermal conditions on the sugar content of the beet. The northern counties furnished 392 samples, with an average weight of 834 grams, equivalent to 29.4 ounces, with an average percentage of 14.3 per cent of sugar in the juice, equivalent to 13.6 per cent in the beet, with an average coefficient of purity of 79.4. The middle section furnished 146 samples, with an average weight of 924 grams, equivalent to 32.6 ounces, with a mean content of sugar of 13.9 per cent in the juice, or 13.2 per cent in the beet, and a mean coefficient of purity of 78. The southern section furnished 69 samples, with an average weight of 892 grams, equivalent to 35 ounces, a mean percentage of 12.8 per cent of sugar in the juice, or 12.2 per cent in the beet, and a mean coefficient of purity of 75.3.

It is seen by the above that there is marked improvement, both in the percentage of sugar and the purity of the juice, in the beets in Ohio as we advance from its southern to its northern border.

The results of the work of the experiment station of Ohio have already been published as Bulletin No. 90 of that station, and interesting details connected with the above data can be found therein. The bulletin also contains interesting maps, showing isothermal lines and conditions of precipitation in the State. The remarks of the authors of the bulletin, namely, Mr. A. D. Selby and Mr. L. M. Bloomfield, on the general character of the results are interesting and are found below:

> Taken as a whole, these analyses seem to indicate that beets of good quality may be grown in most counties of the middle and northern sections of Ohio, and, further, that many portions of the southern section may be adapted to sugar-beet growing, although on the whole less promising than more northerly districts. The analyses from Fayette, Pickaway, Ross, Pike, and Perry counties appear encouraging. The sugar content in Ross County is decidedly reassuring, though the purity is slightly below the standard. Judging by the samples, this might have been greatly improved by more careful culture and better selection of typical specimens. The unfavorable results in Greene and Montgomery counties are not taken to indicate what may really be done in these counties. For the southern section, and particularly the valley districts, further trials should be made. Close planting should be practiced on rich lands.
>
> For the middle section, as a whole, good sugar beets may apparently be grown when growers have learned what to avoid in planting and culture. The low averages in samples from Mercer, Hardin, and Coshocton counties may not certainly be taken as conclusive evidence of conditions unfavorable to sugar-beet culture. Those reported from sandy soils in Mercer County show a fair purity. The results from Belmont, Muskingum, and Tuscarawas counties point to better things in the eastern counties than previously anticipated. More trials in this region another year are certainly warranted by these analyses.
>
> As anticipated from previous trials, it is the northern section which makes the most favorable showing as a whole. Samples were received from every county of the northern section except Trumbull, Mahoning, Hancock, and Allen. A sample was received from Columbiana County after the tables had been completed. While the lake shore district shows to good advantage here, the counties situated along the summer isothermal of 70° F. are but slightly, if at all, inferior, though represented by a much larger number of samples. Ottawa County gives a low purity with a high sugar content, 15.7 per cent. It will be noted that a large number of samples is not conducive to extremely high averages in the tables.
>
> In fact, practically all the counties of the State show a rather high sugar content, 14 per cent in juice when all are averaged, and it is to the coefficient of apparent purity that we must direct our attention to discover differences. Under all the circumstances an average purity of 78 and above may be taken as fairly satisfactory for the present year's analyses.

It is to be borne in mind, when these results are considered, that the percentages were obtained for the most part in comparatively fresh samples, from which only the leaves had been removed. Topping the beets, as for factory use, was not encouraged, owing to the risk of water loss by evaporation. This has led, possibly, to lower percentages than where beets were topped and sent considerable distances by mail. While the actual sugar content would be but slightly, if at all, reduced by loss of water, the apparent sucrose per cent would be changed.

OKLAHOMA.

Only one sample of beets was received at the laboratory of the Department of Agriculture from Oklahoma. The average weight of the beets composing the sample was 10 ounces, the mean percentage of sugar in the beets 11.8, and the coefficient of purity, 72.5. The director of the agricultural experiment station has submitted the following report of the analyses of 21 samples, showing a mean percentage of sugar in the juice of 12, and in the beet of 11.4, and a mean coefficient of purity of 65.3. The mean coefficient of purity as obtained at the experiment station of Oklahoma is phenomenally low. These data, taken in connection with the climatic conditions which prevail in that Territory, are sufficient to indicate that there is no prospect of establishing a beet-sugar industry in Oklahoma.

RESULTS OF EXPERIMENTS IN OKLAHOMA.

Seed and culture directions were sent to farmers in each county, and the number of requests for seed quickly exhausted the available supply. But twenty-four reports were received and twenty-one authentic samples examined. Of the three total failures reported, one is stated as due to flood, another to drought, and the third to hail. The yield, judging from the vague and indefinite reports which I have been able to secure, varied greatly. It seems that in many cases the seed was sown too far apart in the drills and that but little regard was paid the culture-directions sent out. In general, a poor stand was secured, and the majority of those reporting are not enthusiastic as to the prospects of the sugar-beet industry in Oklahoma.

I inclose a tabular statement of the results of analyses of beets. The low coefficient of purity of the juice is especially noticeable.

Analyses of sugar beets grown in Oklahoma Territory, 1897.

County.	Sugar in juice.	Coefficient of purity.	County.	Sugar in juice.	Coefficient of purity.
	Per cent.			*Per cent.*	
Canadian	9.3	53.1	Logan	9.3	58.1
Do	13.0	66.3	Oklahoma	14.0	78.6
Do	10.1	62.7	Pawnee	12.2	68.5
Cleveland	13.0	74.3	Payne	17.7	72.5
Custer	13.9	68.1	Do	11.9	54.3
Garfield	12.6	67.3	Do	11.8	64.3
Kingfisher	14.9	66.2	Do	11.8	63.1
Lincoln	10.8	73.0	Do	8.4	52.1
Do	10.8	57.7	Pottawatomie	12.8	61.2
Do	13.9	81.8			
Do	10.1	60.1	Average	12.0	65.8
Logan	9.6	68.6			

OREGON.

No samples of beets were received at the Department from the State of Oregon during the season. Previous analyses of beets received from that State have shown uniformly a high content of sugar and a high coefficient of purity. The agricultural experiment station of Oregon for several years has devoted a great deal of time and attention to the study of the sugar-beet industry in that State and published valuable reports on the subject. Mr. G. W. Shaw has prepared a résumé of the work of the station and of the Department, which contains the summaries of the work done, with various comments on the data obtained. This report is given below.

RESULTS OF EXPERIMENTS IN OREGON.

In his notes on the analyses of beets for the season of 1891, Dr. H. W. Wiley, chemist of the United States Department of Agriculture, said: "The samples from Oregon are uniformly rich in quality, and if they truly represent the capabilities of the State there is certainly a bright future for the sugar-beet industry on that portion of the Pacific coast." This was said relative to a series of 33 analyses made at the United States Department of Agriculture, which gave the following average results: weight, 644 grams; sugar in the juice, 14.5 per cent; purity, 82.2.

It was to obtain a decided answer to the question, "Does Oregon possess the requisite conditions for the manufacture of sugar from beets?" that the writer, as chemist of the Oregon Experiment Station, began a series of experiments with beets in 1891, which were continued in 1892 and again in 1897. The results of these investigations are here briefly set forth, more detailed account of which may be had by applying to the station for Bulletin No. 44.

The sugar beet does not differ from other plants in requiring certain conditions of climate and soil to give favorable results. In foreign countries both of these questions have been pretty satisfactorily settled, but in some parts of the United States the plant seems to thrive under very different conditions than obtain in foreign countries. Notably is this true concerning the rainfall, as is illustrated in the case of California and Utah, as well as in the experimental culture in Oregon, as will appear later; hence foreign countries can not be taken as representing the only conditions under which the root will thrive. However, it does there thrive and these conditions can by no means be ignored. It also thrives, and that splendidly, in our own California, hence her conditions can not be disregarded in a consideration of this question. Let us examine Oregon's condition of climate and soil that, if possible, we may obtain some a priori ideas on these lines.

The season for the growth of beets may be divided into three periods—that of germinating, that of plant formation, and that of sugar storing. The following is a comparative table showing the temperature averages for Germany and certain parts of Oregon during these periods:

Average temperature for periods of growth.

Period of growth.	Average temperature.			
	Foreign.	Eastern Oregon.	Willamette valley.	Southern Oregon.
First	49.1	56.0	52.5	53.3
Second	63.3	65.0	64.4	64.5
Third	56.3	64.5	63.3	54.8

Taking as a basis Dr. McMurtrie's mean isotherm for sugar-beet culture at 70° for June, July, and August, Dr. Wiley, in his report upon beet culture, gives a map of the United States, showing 100 miles on each side of this isotherm, within which area favorable results may be looked for.

It is in the rainfall of the State that we find the greatest seeming deviation from those portions of the world which are taken as typical beet-producing regions. This seeming difference should not be considered as a too serious drawback, nor would it appear so to those acquainted with all the conditions. The average amount of rainfall does not differ much from that of the beet-growing regions of other countries, yet it is not so evenly distributed. It must be borne in mind, however, that the soils of Oregon are much different with respect to their retentiveness of moisture, and that for all our crops the necessary moisture nearly all falls during the "wet season," and for this reason we do not usually consider the monthly rainfall as bearing so close relation to the crops as it does in most other States, but rather are wont to consider the seasonal precipitation as the more important factor. In this respect ours is similar to the condition which obtains in our sister State, California, in which the beet industry has reached a high state of development.

Champion and Pellet consider phosphoric acid as an indispensable base for the formation of sugar in the beet. They classify the order in which the plant food is indispensable as follows: (1) Phosphoric acid, (2) lime, (3) nitrogen, (4) potash.

It is foreign to our purpose to discuss, at this time, the soils of Oregon to any length, but in connection with the last statement I desire to direct attention to the fact that the soils of Oregon are well—yes, abundantly—supplied with phosphoric acid; that they surpass those of France in lime and equal them in potash. Below are contrasted analyses of some of the French sugar-beet soils with those of the natural divisions of this State and those of California. These results, I think, speak for themselves, and need no further comment.

Average comparative composition of soils.

Analysis of fine earth.	France.		Oregon.			California.
	Somme.	Nord.	Eastern.	Willamette Valley.	Southern.	
Insoluble matter	81.80	82.50	66.59	65.18	62.45	67.88
Soluble silica			13.12	5.02	8.74	8.96
Potash (K_2O)	.06	.14	.43	.23	.34	.64
Soda (Na_2O)	.09		.22	.18	.21	.28
Lime (CaO)	.51	.42	1.22	.83	2.22	1.08
Magnesia (MgO)	....	....	.75	.79	.80	1.49
Manganese (Mn_3O_4)	....	....	.10	.08	.25	.06
Iron (Fe_2O_3)	2.88	2.18	10.69	16.45	15.35	15.02
Alumina (Al_2O_3)	7.24	8.62				
Sulphuric acid (SO_3)	....	....	.04	.03	.01	.05
Phosphoric acid (P_2O_5)	.09	.08	.14	.21	.13	.08
Carbonic acid (CO_2)	.40	.70	....	....	....	....
Water and organic matter	5.60	4.84	6.21	10.77	9.52	4.40
Other matter	1.85	1.52	....	....	....	....
Humus	....	....	1.44	1.63	2.25	.75

Measured, then, by the foreign conditions as to temperature and the California conditions as to rainfall, and with a soil amply supplied with all the elements necessary to produce abundant crops, Oregon would certainly seem favored with all the requisites for success in beet culture.

The analyses made at the station during the season of 1891–92 may be summarized as follows:

County averages for 1891.

County.	No.	Sugar.	Purity coefficient.	County.	No.	Sugar.	Purity coefficient.
Benton	39	12.30	74.12	Marion	1	15.99	78.38
Clackamas	7	14.55	77.30	Polk	1	14.72	78.08
Columbia	1	13.74	79.42	Union	3	15.84	79.89
Douglas	9	12.99	73.45	Washington	11	13.96	78.79
Jackson	3	18.93	80.99	Yamhill	1	10.73	76.64
Lane	16	14.32	79.95				
Linn	5	13.54	79.91	Average	....	14.13	78.08

An examination of the results reveals that the analyses had a wide range, viz: From 6.77 per cent to 22.44 per cent sugar in the juice. Of the 95 analyses made, 8 fell below 10 per cent; 76 showed over 12 per cent, and 37 over 14 per cent sugar. An average of 81 analyses for the Willamette Valley shows 13.76 per cent sugar and a purity coefficient of 77.89; the average beet weighing a little over 1¼ pounds, while an average of 10 analyses of beets from southern Oregon showed 13.38 per cent sugar with a little larger beet. But this does not really show the capabilities of this section of the State, as will appear later, for there were quite a number of immature beets included in this average.

Experiments of 1892.—For the investigations of 1892 the following varieties were used, Desprez's Early Rose, Vilmorin's Improved, Kleinwanzlebener, and White Imperial, all of which are favorite kinds, the first being much used in California. Unfortunately the seed was delayed in reaching us, so it could not be distributed to the farmers as early as it should have been to secure the best results. Had the seed reached us in due time, it could have been put into the ground in April, for at that time there was favorable weather for seeding, but by the time the seed had been distributed cold weather set in and continued till May, after which the weather became very dry, rendering the conditions for a fair trial very unfavorable.

The rainfall for the season was below the normal and reports all read "very dry," "extraordinarily dry," "weather very unfavorable." In fact, nearly all the beets in the eastern portion of the State failed to mature, and in many instances the seed failed to germinate. So far as the season's climate is concerned, then, the experiments were greatly handicapped and we were "in pursuit of knowledge under difficulties."

The cultivation for this season was the same as for the previous year, except that the rows were placed 20 inches apart.

Owing to the disturbed condition of the experiment, the results are doubtless poorer than would have been the case had the season been one of more nearly normal conditions. Still, the results confirm the conclusions of the previous year, that Oregon possesses the conditions necessary for the production of excellent beets for the purpose of beet-sugar manufacture.

Expressed by counties the averages are as follows:

Averages for 1892 by counties.

County.	Number of analyses.	Average for 1892.	Purity coefficient.	County.	Number of analyses.	Average for 1892.	Purity coefficient.
Benton	17	12.80	86.50	Polk	5	14.50	73.30
Clackamas	1	15.10	87.83	Union	7	19.80	87.33
Douglas	9	15.20	81.15	Washington	10	15.50	78.79
Jackson	1	15.00	84.74	Yamhill	5	13.70	82.83
Lane	2	15.20	84.05	Josephine	2	15.70	88.00
Lincoln	3	16.20	83.00	Wasco	1	21.10	90.50
Linn	1	17.10	73.74	Malheur	1	20.20	84.90
Marion	2	13.80	74.60				

The average of all analyses for the State was 15.7 per cent sugar in the juice, with a purity coefficient of 78.08, against 13.75 per cent and a purity of 77.57 for the previous season. Out of the 65 analyses made, only 11 indicated less than 12 per cent sugar in the juice, and 41 samples indicated over 14 per cent, the extremes being 9.4 per cent and 23.8 per cent. The average for the different natural divisions of the State were as follows:

	Per cent.
Willamette Valley, 44 samples	14.7
Eastern Oregon, 11 samples	19.2
Southern Oregon, 10 samples	15.1

While from 1893 to 1897 no definitely outlined experiments have been conducted, yet the station has furnished more or less seed to various parties who have sent the beets to be analyzed. In other cases beet seed has been furnished by other parties, and analyses have been made in all cases when beets were forwarded to the station. The average of the results of 23 analyses made since 1892 shows 15.05 per cent sugar in the juice and a purity coefficient of 89.8.

Average of all results.—Let us now collect the results to 1897 which have been thus separately set forth. In the same table I beg to include the averages from analyses made at Washington, D. C., by the United States Department of Agriculture. These last-mentioned results really indicate a little too high, probably about 10 per cent, on account of the time that necessarily elapsed between harvesting and analyzing, which would result in a loss of water.

Expressed by counties the averages are as follows:

Average of all analyses for each county.

County.	Number of analyses.	Average of analyses made at station.	Purity coefficient.	Number of analyses.	Average for United States Department of Agriculture.	Purity coefficient.
Benton	42	12.57	79.63	5	14.34	82.8
Clackamas	8	15.62	78.76	3	15.86	84.2
Columbia	1	13.74	79.42	3	15.30	81.7
Coos	0			5	14.56	82.6
Douglas	18	14.10	77.98	1	17.74	84.3
Jackson	4	17.93	81.00	1	18.94	83.9
Lane	18	14.42	80.19	6	14.24	85.4
Lincoln[1]						
Linn	6	14.13	73.43	1	14.15	79.4
Marion	4	15.17	74.60	2	14.15	81.1
Polk	16	14.54	74.10	1	12.10	79.8
Union	30	18.61	85.10	2	14.35	81.8
Washington	2	15.29	80.98	3	12.49	80.7
Yamhill	7	12.87	82.76	0		
Josephine	2	15.70	81.21	0		
Wasco	1	21.10	90.50	0		
Malheur	1	20.20	83.44	0		
Sherman	0			1	13.55	72.2
Umatilla	0			1	15.12	80.9
Multnomah	1	16.90	76.80			

[1] Averaged with Benton County.

If we omit from the average those beets which were immature or overgrown, the averages for the State will be:

	Sugar.	Purity coefficient.
Season of 1891	14.3	78.2
Season of 1892	15.9	81.4
Since 1892	15.0	84.8
Mean	15.0	81.5

During the season just ended, 1897–98, the experiments were continued, but were limited for the most part to those portions of the State which seemed to offer not only the best conditions for growing beets, but also presented other favorable economic conditions, for unless the requisites for the manufacture of sugar can be had as well as the beets, it is useless to expend labor in an attempt to show that we can grow good beets. In these experiments the conditions were not particularly favorable—indeed, were adverse, inasmuch as the ground was entirely prepared in the spring and the seed was late. The results obtained in the localities selected are given below:

County.	Weight.	Sugar.	Purity coefficient.
	Grams.	*Per cent.*	*Per cent.*
Washington	395	15.2	85.9
Clackamas	508	13.8	83.4
Union	477	17.5	88.4
Jackson	437	15.6	81.0
Miscellaneous	512	14.1	85.8

PENNSYLVANIA.

Fifty-nine samples of beets grown in Pennsylvania were received at the Department of Agriculture laboratory for analysis. The mean weight of the beets in the samples was 18 ounces, the mean content of sugar in the beet 13.8 per cent, and the mean coefficient of purity, 79.5. The size and sugar content of the samples received from the whole State were satisfactory, but the coefficient of purity falls a little below the minimum standard.

The samples received may be divided, for the purposes of study, into two sets, namely, those from counties lying in and north and west of the favorable thermal belt, and second, the counties lying south and east of that belt. Collected by counties, the samples divided according to the above classification show the following data:

Counties of Pennsylvania above and below isothermal line 70°.

County.	Number of samples.	Average weight.	Sugar in the beets.	Coefficient of purity.
Above 70°.		*Ounces.*	*Per cent.*	
Allegheny	13	18	13.8	77.0
Crawford	3	25	13.9	75.3
Elk	2	16	13.0	77.4
Erie	7	28	15.8	82.5
Mercer	2	34	15.4	83.7
Potter	1	18	18.0	81.1
Union	1	10	19.6	....
Lawrence	2	16	16.8	79.9
Averages, etc	31	21	14.8	78.9
Below 70°.				
Cumberland	22	12	12.2	79.6
Lebanon	1	24	14.4	79.0
Perry	2	31	15.7	82.2
York	3	25	13.9	80.2
Averages, etc	28	15	12.7	79.8

It will be seen that the 31 samples coming from the counties lying in and to the north and west of the favorable thermal belt have an average weight of 21 ounces, a mean content of sugar in the beet of 14.8 per cent, and a mean coefficient of purity of 78.9. The 28 samples coming from counties lying south and east of the favorable thermal belt have a mean weight of 15 ounces, a sugar content in the beet of 12.7

per cent, and a mean purity of 79.8. With the exception of the coefficient of purity, the influence of the more favorable thermal conditions is easily distinguished.

Of the counties in Pennsylvania furnishing the most data may be mentioned Allegheny, with 13 samples, having an average weight of 18 ounces, a mean content of sugar in the beet of 13.8 per cent, and a mean purity of 77. Cumberland County, in the southern part of the State, sent 22 samples, having a mean weight of 12 ounces, a mean content of sugar in the beet of 12 per cent, and a mean purity of 79.6. Erie County sent 7 samples, having a mean weight of 28 ounces, a mean content of sugar in the beet of 15.8 per cent, and a mean purity of 82.5. The samples from Erie County are decidedly the most favorable, and this is to be expected, since Erie County has conditions of soil and climate which are entirely analogous to those pervading the New York area from Albany to Buffalo.

Attention has been called before to the mountainous character of a large part of the State of Pennsylvania, even where favorable thermal conditions prevail. It is evident, however, that in the northern and western portions of the State, where suitable soil can be found, the culture of the sugar beet may be introduced under the most favorable conditions, and with every prospect of success.

EXPERIMENTS CONDUCTED BY THE AGRICULTURAL EXPERIMENT STATION.

The agricultural experiment station of Pennsylvania cooperated with the Department of Agriculture in the investigation of the beet-sugar work, and has published the results of its work in Bulletin No. 40 of that station. For details of the analytical work and of the observations made by the director of the station the reader is referred to the bulletin mentioned. In discussing the analyses Director Armsby says:

> Of the 69 samples reported upon in the above table, 55 (or 80 per cent) showed over 12 per cent of sugar in the beet. Thirty-four samples (or 49 per cent) showed a coefficient of purity of over 80. Thirty-two out of the total number (or 46 per cent) showed over 12 per cent of sugar and also a purity coefficient of over 80. In view of the fact that practically all of the beets were raised by farmers who had had no experience in the culture of this plant for sugar, the results must be regarded as decidedly favorable so far as the quality of the beets is concerned.
>
> In 40 cases out of the whole number we have data regarding the average weight of the beets. Of these 40 samples, 14 (or 35 per cent) weighed between 0.80 and 1.35 pounds, 18 (or 45 per cent) were below 0.80 pound in weight, and 8 (or 20 per cent) were above 1.35 pounds. It thus appears that, as a rule, the size of the beets was rather small.
>
> Thirty-four of the experimenters reported the yield of beets. In most cases the yield was calculated from that of a comparatively small area, and in many cases there is evidence that the results may be considerably in error. Taking them as they stand, however, 10 (or 29 per cent) reported a yield of over 15 tons per acre, 2 (or 6 per cent) a yield of between 10 and 12 tons per acre, and 17 (or 50 per cent) a yield below 10 tons per acre. It thus appears that while, as stated above, the general quality of the beets was good, the yield was rather small.

As stated above, 32 of the samples showed more than 12 per cent of sugar with a purity coefficient of more than 80. Of these 32 experiments, 7 (or 22 per cent) reported a yield of over 10 tons per acre, 4 (or 13 per cent) a yield of between 8 and 10 tons per acre, 7 (or 22 per cent) a yield of less than 8 tons per acre, while 14 (or 44 per cent) did not report the yield. These figures confirm those given above in showing that the yield was, as a whole, rather small.

RHODE ISLAND.

Only 2 samples were received from Rhode Island, and no deductions of any value can be made from such limited data. The average weight of the beets composing the samples was 21 ounces, the mean percentage of sugar therein 11.9, and the mean purity 74.2. These data of course are far from encouraging, but there are reasons for supposing that the climate of Rhode Island is favorable to the production of a much richer beet. The available area for cultivation in beets in Rhode Island is small, and it may not be worth while to prosecute the experimental work. Nevertheless, it is suggested that it might be profitable for the agricultural experiment station of Rhode Island to study the subject to a greater extent.

SOUTH CAROLINA.

Thirteen samples were received at the Department of Agriculture from South Carolina. The mean weight of the samples was 17 ounces, the percentage of sugar in the beet 9.9, and the mean purity 79.9. These data, taken into consideration with the latitude and thermal conditions, indicate that there is no prospect of South Carolina becoming a sugar-producing State.

SOUTH DAKOTA.

Only 5 samples of beets grown in South Dakota were received at the Department for analysis. The mean weight of the beets composing these samples was 17 ounces, the mean content of sugar in the beet 15.1, and the mean purity coefficient 83.2. These data are favorable, but too meager for the basis of any definite conclusions.

EXPERIMENTS BY THE AGRICULTURAL EXPERIMENT STATION OF SOUTH DAKOTA.

Extensive investigations in cooperation with the Department of Agriculture were carried on by the South Dakota station during the past season. The whole number of samples analyzed at the South Dakota station was 337. For convenience of classification they are grouped according to the different regions in the State, and by counties in the regions as is shown in the following table:

Averages by counties and regions.

[From report of Jas. H. Shepard, Chemist of Experiment Station.]

Region and county.	Number of samples.	Tons per acre.	Per cent stand.	Average weight.	Sugar in beets.	Purity coefficient.	Ash in the juice.
BIG STONE LAKE REGION.							
				Grams.	*Per cent.*		
Roberts County	3	24.6	90	387	15.3	88.0	0.85
Grant County	7	16.4	71	397	13.9	87.5	.90
Region averages	....	20.5	81	392	14.6	87.8	.88
UPPER SIOUX RIVER REGION.							
Codington County	4	15.7	60	473	12.9	85.1	.87
Deuel County	4	8.5	83	423	14.5	89.2	.60
Kingsbury County	14	23.1	85	359	14.0	86.2	1.00
Moody County	5	14.1	79	431	14.2	87.8	1.15
Lake County	4	16.6	72	424	13.8	81.2	1.09
Brookings County	26	19.8	74	455	13.4	86.7	.88
Minnehaha County	24	20.2	77	423	15.2	86.1	1.08
Region averages	....	16.9	76	427	14.0	86.0	.95
LOWER SIOUX RIVER REGION.							
Lincoln County	9	16.4	81	402	15.0	84.8	1.17
Turner County	9	18.2	55	437	14.5	85.1	1.12
Hutchinson County	1	19.5	80	333	19.5	88.4	1.20
Bonhomme County	10	17.5	77	449	15.4	87.2	.99
Clay County	18	30.5	88	470	14.7	86.2	1.15
Yankton County	22	19.7	77	498	14.6	86.0	1.03
Union County	18	19.3	79	388	15.2	88.5	.81
Region averages	....	20.2	77	425	15.6	86.6	1.06
CENTRAL JAMES RIVER REGION.							
Miner County	4	21.5	47	329	14.5	84.6	2.06
Sanborn County	7	14.2	64	373	15.5	87.4	.92
Davison County	9	30.1	81	470	14.8	86.4	.91
McCook County	2	22.5	75	423	15.0	89.0	1.03
Region averages	....	22.1	67	399	14.9	86.9	1.23
UPPER JAMES RIVER REGION.							
Marshall County	3	....	90	322	13.7	85.6	.76
Brown County	19	15.1	61	364	13.3	81.7	1.06
McPherson County	2	26.3	100	314	18.3	85.3	.73
Edmunds County	3	17.7	75	349	15.1	84.3	1.18
Day County	10	14.5	69	367	13.9	88.3	.91
Clark County	8	22.8	75	351	13.9	87.2	1.08
Spink County	5	19.1	75	362	15.5	89.1	1.09
Beadle County	13	33.6	77	475	14.5	86.8	1.06
Faulk County	2	12.8	95	304	18.0	89.5	1.28
Hyde County	2	14.3	50	488	14.6	84.7	1.00
Hand County	2	11.8	90	259	16.8	81.4	1.27
Region averages	....	18.8	78	360	15.2	85.8	1.04
UPPER MISSOURI RIVER REGION.							
Campbell County	2	12.3	55	427	17.7	89.2	1.20
Walworth County	2	16.6	95	389	14.9	84.8	1.11
Potter County	4	17.2	59	409	15.9	88.0	1.12
Sully County	1	12.5	90	525	14.3	86.7	1.12
Hughes County	3	8.3	55	399	14.8	85.3	1.09
Region averages	....	13.4	71	430	15.5	86.8	1.13
CENTRAL MISSOURI RIVER REGION.							
Jerauld County	6	11.0	76	290	15.3	84.5	1.28
Buffalo County	2	44.0	85	379	16.1	84.3	1.17
Brule County	7	17.2	75	375	16.2	82.4	1.38
Aurora County	5	14.7	73	394	16.6	86.7	1.10
Douglas County	2	16.8	70	286	16.4	87.8	.99
Charles Mix County	3	23.9	85	394	14.8	83.2	1.25
Region averages	....	21.3	77	336	15.9	84.8	1.19

Averages by counties and regions—Continued.

Region and county.	Number of samples.	Tons per acre.	Per cent stand.	Average weight.	Sugar in beets.	Purity coefficient.	Ash in the juice.
WHITE RIVER REGION.							
				Grams.	*Per cent.*		
Presho County	1	45.0	....	421	14.9	83.1	.90
Pratt County	1	33.0	100	445	14.3	82.0	1.07
Gregory County	1	....	....	263	16.4	80.8	1.22
Region averages	....	39.0	100	376	15.2	82.0	1.06
BLACK HILLS REGION.							
Meade County	10	16.1	75	401	16.8	82.1	1.19
Pennington County	5	9.5	79	330	16.4	82.7	1.48
Custer County	1	10.0	80	67	14.8	78.0	.47
Fall River County	4	15.4	90	325	15.9	83.7	1.35
Region averages	....	12.8	81	281	16.0	81.6	1.12
BUTTE REGION.							
Harding County	4	....	35	343	20.7	86.0	1.30
Butte County	4	33.8	78	471	16.5	89.4	1.18
Region averages	....	33.8	57	407	18.6	87.7	1.24
State averages	....	21.9	77	383	15.5	85.6	1.09

From an inspection of the above data it is seen that the results of the experiments conducted by the station are quite encouraging. The mean average weight of the beets analyzed was a little below the normal, 383 grams, equivalent to 13.5 ounces. The mean content of sugar in the beets was 15.5 per cent, and the mean purity coefficient 85.6. The data for yield per acre are probably unreliable, as many reports of tonnage are given which are evidently erroneous, as, for instance, in Presho County, where a yield of 45 tons per acre is reported, and in Pratt County, 33 tons per acre, a quantity of beets which is not to be expected under the most favorable circumstances of growth. In so far as producing a crop of beets rich in sugar is concerned, the conditions in South Dakota seem to be extremely favorable. Attention, however, should be called to former statements that the farmers of this State will have to contend with the great difficulty of an early and sudden coming of winter. If, therefore, the industry should secure a hold, this will be the most important point in the agricultural part of the work to be considered, namely, the harvesting and preserving of the crop for manufacturing purposes. The high purity coefficients which obtain in South Dakota are especially encouraging. There is no other State which has equaled South Dakota in the purity of the juices of the beets. There is abundant reason found in the data published above to encourage the agricultural experiment station of the State to continue its work of investigation, and to attract the favorable attention of intending investors.

TEXAS.

The northwestern portion of Texas reaches an altitude where the thermal conditions become more favorable to beet production. It is not to be expected that the southern and western portions of the State will ever be seriously considered for this purpose.

Eleven samples were received from Texas at the Department of Agriculture laboratory, having an average weight of 22 ounces, a mean content of sugar in the beets of 12.6 per cent, and a mean purity of 76.5. All the counties represented were in the northern and western portions of the State except McLennan, which is in the center. There is reason to believe that on the high plateaus in the northwestern portion of the State, where irrigation is possible, the culture of the sugar beet might be introduced with considerable prospects of success.

A few analyses were made by the agricultural experiment station of Texas, and these are given below:

REVIEW OF THE WORK DONE BY THE AGRICULTURAL EXPERIMENT STATION OF TEXAS.

All of the seeds that we received for distribution in this State during the past season came to hand too late for proper planting in a State so far south as Texas. For this reason the dry season prevented a fair growth of the beets at an important period in their development, and the crops waited for the fall rains to develop size. These fall rains were accompanied by a small per cent of sunshine, resulting in a low sugar content. These conclusions are based upon the fact that where beets were planted late and irrigated, the sugar content was higher than when samples were grown by late fall rains and then sent us for analysis. Of course the extreme western portion of the State produced beets of high sugar content.

Results of experiments in Texas.

Name and address of persons from whom beets were received.	Section of State.	Laboratory number.	Brix.	Sucrose.	Purity coefficient.	Weight.	
						Lbs.	*ozs.*
R. B. Edgell, Clarendon, Donley County, Tex.	Panhandle □	1	16.8	11.88	70.68	1	10
D. W. Ruckston, Silverton, Briscoe County, Tex.	do	1	15.5	9.69	62.5	2	4
Do	do	2	17.0	11.02	64.82	2	6
Do	do	3	14.0	6.89	49.19	2	10
Do	do	4	13.2	7.98	60.91	3	11
R. L. Goble, Garrett, Ellis County, Tex.	Black Land Belt □	(*)	13.5	7.79	57.7	1	11
L. H. Carpenter, Silverton, Briscoe County, Tex.	Panhandle □	1	15.2	6.27	41.8	1	5
Do	do	2	13.5	4.89	36.9	1	11
Do	do	3	11.0	5.04	45.7	2	6
Do	do	4	11.3	5.46	48.34	3	2
F. E. Davis, Dublin, Erath County, Tex.	Central North ⌂	†1	12.55	7.07	56.04	2	11
		1	16.5	9.69	58.7	1	7
C. W. Griffin, Toyahvale, Reeves County, Tex.	Pecos Region □	†1	15.0	9.5	63.3	1	6
Do	do	2	21.1	15.08	71.5	1	8½

* 4 beets, 1 sample. † Red.

TENNESSEE.

Seventeen samples of beets were received at the laboratory of the Department of Agriculture from Tennessee, of which eight were from the agricultural experiment station at Knoxville. The mean weight of the beets received was 11 ounces, the mean percentage of sugar 10.8, and the mean purity 71.9. The mountainous regions of Tennessee are probably favorably situated in regard to thermal conditions for the growing of beets, but the contour of the country will prevent any extensive planting of this crop. Middle and western Tennessee are evidently too warm for successful beet culture.

VIRGINIA.

Thirty-four samples grown in the State of Virginia were received at the Department of Agriculture for examination. The mean weight of the beets composing these samples was 21 ounces, the mean content of sugar in the beets 11.6 per cent, and the mean purity 76.2.

Virginia lies almost entirely south of the region where thermal conditions are most favorable to beet culture. It is only in the seacoast counties, where the temperature is moderated by the sea breezes, and in the mountainous counties, where the altitude is great enough to lower the temperature, that good results can be expected. A great deal of interest has been manifested in the State in regard to the building of factories, but it is evident that intending investors as well as farmers should stop to consider the matter very seriously before investing their money and their labor in this enterprise.

A few analyses received from Virginia show favorable results, as for instance, the sample from Carroll County, weighing 15 ounces, and containing 15.4 per cent of sugar in the beet. There is little in the data, however, to encourage the belief that Virginia is a favorable region for beet growing.

Investigations were also made by the agricultural experiment station of Virginia, but only to a very limited extent. The data obtained on analysis, together with the observations of the official in charge of the investigations, are found in the following report:

INVESTIGATIONS BY THE AGRICULTURAL EXPERIMENT STATION OF VIRGINIA.

Before stating the results of the analyses made at this station I think it best to make some comments upon the work attempted this season. In the first place, it was quite late before we concluded to undertake the distribution of seeds and then by the time they reached us from the Department of Agriculture the season was so far advanced that a considerable number of persons to whom the seeds were distributed failed to plant them. This, of course, disturbed the experiment to a considerable extent. Another disturbing factor was the extreme drought which prevailed during the latter part of the season over this State in general, which resulted in many cases in practically destroying the crop. As a consequence, our results are not what we could wish. After much correspondence with those to whom seed was distributed, we concluded to analyze only samples representing fairly well the tide-water and limestone sections of the State. The results of these analyses follow:

Sample No. 1. From W. J. Phillips, Accomac County, Va. Weight of whole beet, 372 grams. Per cent of sugar, 16.11.

Sample No. 2. From Henry Jones, Suffolk, Nansemond County, Va. Weight of whole beet, 1,325 grams. Per cent of sugar, 4.17.

Sample No. 3. From L. T. Barnes, Boulevard, New Kent County, Va. Weight of whole beet, 581 grams. Per cent of sugar, 14.64.

Sample No. 4. From T. A. Eller, Atkins, Smyth County, Va. Weight of whole beet, 760 grams. Per cent of sugar, 9.61.

Sample No. 5. From experiment station. Weight of whole beet, 584 grams. Per cent of sugar, 13.63.

The first three samples represent the eastern section of the State and the last two the limestone section. We endeavored to secure sixteen samples covering more perfectly the geologic areas of the State, but from the causes above mentioned we failed to procure proper samples.

Dr. McBryde desires me to say that if the Department wishes us to aid in the conduct of this work the coming year we will be pleased to do so, and that the work will be taken in hand in proper season and the growing experiments arranged on a much better plan, so as to secure reliable samples from the different sections of the State.

Experiments in the growth of beets in Virginia during 1897 were also made by the State board of agriculture, and are described on page 206 of the annual report of the board for the year 1897. One hundred and eight samples were analyzed during September and October. It is stated in this report that these samples varied in saccharine strength from 8.5 to 17.1 per cent; thirty-five of them were below 12 per cent, and seventy-three showed a saccharine value of from 12 to 17.1 per cent, with a coefficient of purity of from 79 to 88.5, or a saccharine average of 14.7 per cent, and an average purity coefficient of 85, which is equivalent to 250 pounds of raw sugar per ton of beets.

The data obtained by the State board of agriculture are more favorable than those secured by the Department of Agriculture or by the experiment station at Blacksburg. It is hardly probable, however, that the map which accompanies the report of the State board of agriculture will be regarded as a final judgment in regard to the localities in Virginia suitable to the growth of beets of the different qualities noted. A much larger series of experiments, extending over a greater number of years, will be necessary to definitely determine that point.

WASHINGTON.

Thirty-four samples of beets grown in the State of Washington were received at the Department of Agriculture for analysis. The mean weight of the beets received was 27 ounces, the mean percentage of sugar 13.7, and the mean purity coefficient 80.7.

The agricultural experiment station of the State of Washington for many years has conducted careful studies in regard to the possibilities of producing sugar in that State. During the past year 60 samples of beets grown in Washington were analyzed at the laboratory of the agricultural experiment station. The mean weight of the beets analyzed was 23 ounces, the mean percentage of sugar in the beets 13.6, and the mean coefficient of purity 75.7. Of the whole number 68 per cent contained over 12 per cent of sugar, and 78 per cent weighed more than 16 ounces. The reports of the director and chemist of the station are given below.

Summary of analyses of beets from Washington.

[Compiled from report of experiment station.]

County.	Number of samples.	Net weight beets.	Sugar in beets.	Coefficient of purity.	County.	Number of samples.	Net weight beets.	Sugar in beets.	Coefficient of purity.
		Ounces.	*Per ct.*				*Ounces.*	*Per ct.*	
Clarke	1	29	14.3	77.7	King	10	15	12.1	71.4
Pierce	7	25	12.0	73.7	Clallam	1	54	14.3	77.4
Lincoln	20	17	15.8	79.2	Whitman	2	46	14.2	76.3
Kitsap	2	22	12.3	70.9	Klickitat	2	26	12.4	74.5
Skagit	8	33	12.5	72.9					
San Juan	4	27	13.5	75.6	Averages, etc.	60	23	13.6	75.7
Whatcom	3	25	11.8	80.4					

RESULTS OF EXPERIMENTS IN WASHINGTON.

I have the honor to report as follows:

The appointment was made so late in the summer that it served only the purpose of providing for the free transportation of beets to this point for analysis, consequently the report must necessarily deal with facts of an earlier date chiefly, if it is to be of any value as an indication of the adaptability of the soil and climate of the State of Washington to the culture of sugar beets. Permit me to say that we regarded our experimentation as practically complete before the beginning of this year. In consequence of this fact it had been announced early in the season that no distribution of seed would be made. At a later period some seed was obtained from the Department of Agriculture. The planting season in Washington begins very early considering the latitude, and the seed was received too late for general use. Seed was, however, supplied to those requesting it, and in the main these requests were from localities not so well adapted to the culture of sugar beets, so that the results of this year's planting can in no way be taken as representative.

The Washington State Experiment Station began the investigation of this problem through its chemical department in the spring of 1894, and conducted it with the greatest thoroughness through that and the two succeeding seasons, making more than 3,000 analyses. Beets were raised in both small and large plats. The results were so uniform as to demonstrate the peculiar adaptability of this region to the culture of sugar beets. These results are given in Bulletins 15 and 26 of the State experiment station. I submit herewith the report of Professor Fulmer, of the department of chemistry, relative to the results of this year. I might mention the fact that Professor Fulmer was for some time chemist of a beet-sugar factory in Nebraska, and is particularly well fitted for dealing with this subject. The results thus far obtained in the State show a percentage of sugar of about 15, and a purity of nearly 84.

PULLMAN, WASH., *January 6, 1898.*

DEAR SIR: In compliance with your request I hand you herewith a tabulated statement of the analyses made in the station laboratory of beets grown from seed furnished by the United States Department of Agriculture. The data presented are far from being complete. The very important item of "variety of seed" is entirely omitted, because in almost all cases the variety indicated by the grower of the beets was not at all in harmony with the characteristics exhibited by the samples. For example, beets with pink skins were often marked "Kleinwanzlebener," which is a pure white variety. It is quite clear to my mind that the lack of harmony between the character of the beets and the names they bore was due to the seed sent out by the Government being a mixed seed.

Parties sending in beets for analysis failed in most cases to send any data concerning the time of planting, thinning, and harvesting; character of soil; amount of cultivation, etc. On account of this great lack of reliable data, the meager results obtained are of little value.

I wish to direct your attention to the fact that this kind of experimental work with sugar beets in our State is at this time a useless expenditure of time and energy. During the past four years this station has made over 3,000 analyses of sugar beets grown in all parts of the State, and under all conditions of temperature and rainfall. The details of these analyses, and of the field experiments, have been published in full in Bulletins 15 and 26. The raising of high-grade beets in this State has been fully demonstrated to be a practical success, and we believe any further experimentation with small plats is wholly unnecessary.

The uniformly excellent results that we have obtained in the past are in striking contrast to the very poor outcome of this year's test. We believe the low sugar content and purity exhibited by the beets this year is due to several causes:

(1) The seed from Washington was received altogether too late in the spring for distribution in time for early planting. In most sections of the State the seed should be planted not later than the middle of April.

(2) Nearly all of the samples were grown in sections of the State that have not heretofore shown any special adaptability to sugar-beet culture.

(3) We believe the seed was of poor quality. In support of this assertion I wish to call your attention to the samples that were raised at Crescent, in Lincoln County. Heretofore this section has always produced high-grade beets. The samples sent in by William Adam, P. Carstens, and the first two of W. B. Warren were grown from Government seed, and gave a very low sugar content and purity. The samples of Wollweber, and the last three of Warren, were grown from seed raised at Crescent last year, and gave most excellent results. These facts and the very general poor quality of samples leads me to regard the seed furnished as an inferior quality.

The inclosed results do not do justice to our State, and I wish to protest against their publication as an index of the character of beets that can be raised here.

Yours, very respectfully,

ELTON FULMER,
Chemist Experiment Station.

Director E. A. BRYAN,
Pullman, Wash.

In regard to the report of the chemist, attention should be called to the fact that he is evidently mistaken in regard to the quality of the seed sent by the Department of Agriculture. This seed was, of course, not of the direct production from high-grade mother beets, but was the ordinary commercial seed which was imported by the Oxnard Company for distribution among their beet growers. It was the same seed which was sent to Michigan and to New York, which produced in those States the excellent results which have been recorded in previous portions of this report. In over 2,200 analyses of beets which were made in this laboratory during the past season, only about 25 samples were received which had a pink skin, and in most cases these were marked with different names. It is possible, however, that a few seeds of this kind may have been mixed in with the large lot of commercial seeds which were imported into this country. The Department of Agriculture neither purchased nor packed the seeds which were distributed, so that the possible admixture of other varieties can not be positively denied.

With the exception of the excessive rainfall on some of the coast areas, it has been demonstrated that the State of Washington is well suited to the growth of beets of a high grade. An extended report on the possibilities of Oregon and Washington for beet production was made in Bulletin No. 5 of this Division, the investigations, which were published in 1885, having been made in the autumn of 1884. A description of the topographical features and climate of western Washington is given on pages 103–104 of that bulletin. The conclusions which I derived from a study of the conditions at the time are given on page 105 in the following words:

> "In view of the preceding description I am inclined to believe that in Washington Territory and Oregon, soil and climate are very favorable to the growth of a sugar beet of high saccharine strength.
>
> "The mildness of the winter is, though to a less degree than in California, favorable to the season of manufacture. With a wise and careful encouragement of the industry I have no hesitation in saying that the prospects for the development of an indigenous sugar industry in the extreme northwestern part of our country are decidedly bright. It is a field worthy the attention both of experimenters and capitalists."

Investigations which have been made subsequent to this period have abundantly verified the predictions given above. The chemist of the station, in the results of his work for 1897, says that the data are not so favorable as were obtained in preceding investigations, but, as he says, the beets analyzed came from parts of the State less favorable to beet culture than did those samples which had previously been examined. The data obtained by analyses of beets received at the Department from Oregon are decidedly favorable. The average size of the beets, 27 ounces, shows the possibilities of a large yield, while both the content of sugar and the purity coefficient are favorable to the production of large quantities of sugar from the beets produced. The thermal conditions which prevail in Washington are noticed in another place. The coast region is cooler than the mean temperature of 69° for the summer months, but, as has been remarked before in more than one place, this is not unfavorable to the production of high-grade beets; on the contrary, rather promotive of it. The mild autumns, especially in the western part of the State, afford ample opportunity for the complete harvest and care of the beets. In considering the data which have been obtained through a long series of years, therefore, it is safe to say that there are extensive areas in the State of Washington which invite the careful consideration of intending investors in the beet-sugar industry.

WISCONSIN.

Forty-two samples of beets were received at the laboratory of the Department from Wisconsin, of which number 31 were grown in Dane County, representing the beets grown by the agricultural experiment station. It is evident, that the mean results of the samples from Wisconsin are influenced in a marked degree by those obtained from the agricultural experiment station. These mean results therefore represent a higher quality of beets than would have been grown in the promiscuous manner already referred to. The mean weight of the beets grown in Wisconsin was 15 ounces, the mean content of sugar therein was 15.8 per cent, and the mean purity 83.3. The small mean size of the beets is due chiefly to the 31 samples received from the agricultural experiment station, of which the average weight was only 11 ounces. With the exception of 1 sample from Outagamie County, which weighed only 8 ounces, the other samples were of good size. Especially is this true of the 3 samples received from Racine County, the mean weight of which was 34 ounces, the mean content of sugar 15.4 per cent, and the mean purity 82.6.

The data obtained by our analyses are encouraging, but, on account of the small number of samples, not convincing. Therefore the following report of the results of the analyses made at the agricultural experiment station will show more conclusively the influence of the character of the soil and climate of Wisconsin on the quality of sugar beets.

EXPERIMENTS CONDUCTED BY THE AGRICULTURAL EXPERIMENT STATION OF WISCONSIN.

Three classes of experiments were conducted by the agricultural experiment station of Wisconsin during the year 1897. An elaborate report of these experiments has already been printed as Bulletin No. 64 of that station. The following interesting summaries represent the principal data obtained:

The three methods were the following:

First method.—A general distribution of seed was made promiscuously to farmers in the State who desired to experiment. In all, 13,766 packages were distributed. Each package contained directions for planting and cultivating the beet. One thousand six hundred and sixty-three samples of beets grown under these auspices were received at the station for analysis. The quality of the beets, together with the analyses of beets grown in 1890, 1891, 1892, and 1897, with a summary for the four years, is shown in the table on page 120.

Results of analyses of sugar beets grown on Wisconsin farms during 1890–1892 and 1897.—Averages by counties.

County.	1890-1892.				1897.				Summary for four years.			
	Number of samples.	Sugar in juice.	Purity coefficient.	Estimated yield per acre.	Number of Samples.	Sugar in juice.	Purity coefficient.	Estimated yield per acre.	Number of samples.	Sugar in juice.	Purity coefficient.	Estimated yield per acre.
		P. ct.	*P. ct.*	*Tons.*		*P. ct.*	*P. ct.*	*Tons.*		*P. ct.*		*Tons.*
Adams	3	11.99	76.1	9.3	6	13.67	75.5	10.2	9	13.11	75.9	9.8
Ashland	.....	.....	.....	.....	5	11.42	74.2	3.0	5	11.42	74.2	3.0
Barron	3	12.74	77.0	17.7	15	12.94	74.3	12.0	18	12.90	74.7	14.1
Bayfield	.....	.....	.....	.....	1	10.96	73.5	16.5	1	10.96	73.5	16.5
Brown	4	10.75	74.9	17.9	101	13.12	75.5	14.0	105	13.03	75.5	14.3
Buffalo	9	13.48	77.4	15.9	8	12.96	75.3	11.2	17	13.24	76.4	13.0
Burnett	.....	.....	.....	.....	2	12.92	75.0	18.0	2	12.92	75.0	18.0
Calumet	8	16.67	82.6	14.7	48	12.61	72.4	11.8	56	13.19	73.8	12.1
Chippewa	13	12.72	77.5	23.6	34	12.18	74.2	11.7	47	12.25	75.2	15.1
Clark	7	14.15	81.4	10.9	61	11.97	74.9	11.7	68	12.19	75.6	11.6
Columbia	19	12.28	74.7	15.5	30	12.68	71.8	13.4	49	12.53	72.9	14.2
Crawford	4	10.09	72.0	15.3	2	12.09	72.3	9.7	6	10.76	72.1	13.1
Dane	14	12.98	76.7	14.4	44	13.51	71.3	12.7	58	13.37	72.6	13.2
Dodge	13	11.77	76.2	20.7	47	12.86	71.9	12.5	60	12.62	73.0	13.8
Door	3	14.59	80.0	21.4	15	15.11	77.4	10.0	18	15.02	77.7	13.0
Douglas	.....	.....	.....	.....	8	13.92	78.8	16.7	8	13.92	78.8	16.7
Dunn	13	12.49	79.8	11.5	26	12.97	73.7	12.6	39	12.86	75.6	12.2
Eau Claire	10	11.70	76.0	14.0	63	10.70	73.8	11.0	73	10.84	74.1	11.5
Fond du Lac	10	12.13	74.1	11.0	38	12.04	71.2	16.6	48	12.07	71.7	15.1
Forest	1	9.64	72.5	6.0	1	11.31	70.2	15.0	2	10.47	71.3	10.5
Grant	9	10.24	69.3	13.2	26	12.21	71.2	13.0	35	11.74	70.5	13.0
Green	6	12.84	77.5	15.2	4	10.16	65.5	1.0	10	11.77	72.7	15.0
Green Lake	1	11.31	78.1	.....	13	12.06	72.9	11.5	14	12.01	73.2	11.5
Iowa	7	11.32	74.9	27.8	1	10.40	70.2	12.0	8	11.20	74.3	22.5
Iron	.....	.....	.....	.....	1	9.96	64.7	15.5	1	9.96	64.7	15.5
Jackson	1	7.79	65.6	.....	64	11.57	77.4	10.6	65	11.51	77.2	10.6
Jefferson	23	13.96	79.0	17.5	13	13.55	72.8	15.0	36	13.81	76.8	16.5
Juneau	6	13.04	76.0	25.3	9	12.34	72.9	6.2	15	12.63	74.1	13.2
Kenosha	1	12.71	78.1	21.8	13	14.31	74.2	15.0	14	14.19	74.5	15.7
Kewaunee	30	13.58	77.1	35.1	74	13.38	75.4	14.2	104	13.44	75.8	16.8
La Crosse	10	12.58	76.1	15.2	60	12.75	80.6	12.5	70	12.72	79.9	13.0
Lafayette	4	12.27	77.0	26.4	6	10.47	66.3	9.4	10	11.19	70.6	16.0
Langlade	1	12.91	81.4	24.1	15	11.51	70.8	11.0	16	11.59	72.1	12.0
Lincoln	3	17.43	85.9	13.1	7	13.09	75.9	4.5	10	14.39	78.9	10.9
Manitowoc	16	12.61	80.4	16.4	49	13.42	74.9	14.4	65	13.22	76.3	14.8
Marathon	9	12.67	76.5	16.1	44	11.99	72.3	12.4	53	12.10	73.0	12.9
Marinette	2	8.77	64.5	28.5	27	13.23	76.6	9.5	29	12.92	75.7	10.9
Marquette	.....	.....	.....	.....	15	13.19	77.7	8.0	15	13.19	77.7	8.0
Milwaukee	6	15.51	83.4	19.8	14	14.17	77.7	15.2	20	14.57	79.4	18.4
Monroe	16	12.32	76.2	12.3	24	12.36	73.1	11.4	40	12.34	74.3	11.8
Oconto	12	13.76	80.7	13.5	11	15.48	79.6	17.4	23	14.56	80.2	15.1
Oneida	.....	.....	.....	.....	4	13.78	75.5	.....	4	13.78	75.5	.....
Outagamie	14	11.48	75.2	23.6	63	13.06	75.4	15.0	77	12.77	75.3	16.6
Ozaukee	5	13.14	79.0	20.7	17	14.00	75.7	11.1	22	13.81	76.5	13.0
Pepin	5	14.71	79.1	11.9	4	11.82	73.7	23.5	9	13.43	76.6	17.7
Pierce	.....	.....	.....	.....	12	12.56	73.2	15.0	12	12.56	73.2	15.0
Polk	1	11.09	75.4	.....	5	11.90	72.6	17.3	6	11.76	73.0	17.3
Portage	8	12.02	75.1	12.5	33	13.12	73.2	8.3	41	12.91	73.6	9.3
Price	.....	.....	.....	.....	7	10.43	67.2	11.0	7	10.43	67.2	11.0
Racine	4	14.27	80.6	10.5	17	13.75	75.3	14.3	21	13.85	76.3	13.9
Richland	9	11.34	79.6	12.9	15	10.61	68.7	15.3	24	10.88	72.8	14.4
Rock	17	12.96	76.7	11.4	36	13.97	73.5	15.1	53	13.64	74.5	14.0
St. Croix	8	12.55	74.7	19.9	18	12.11	72.2	13.3	26	12.24	73.0	15.3
Sauk	8	9.67	71.5	23.8	23	12.78	72.4	13.0	31	11.98	72.2	14.8
Sawyer	1	10.69	73.8	26.1	.....	.....	.....	.....	1	10.69	73.8	26.1
Shawano	7	12.53	76.3	16.9	28	13.35	75.0	8.2	35	13.19	75.3	10.4
Sheboygan	27	11.71	74.3	16.8	55	12.96	78.0	15.1	82	12.55	76.8	15.6
Taylor	15	13.61	78.9	8.8	10	10.87	70.6	13.6	25	12.52	75.5	11.0

It will be noticed that the table includes the analyses of 527 samples collected during the years 1890–91–92, together with the 1,663 collected in 1897, or a total of 2,190 samples. In the discussion of the analytical data Mr. F. W. Woll, who has compiled the report, makes the following interesting observations:

Sixty-eight of the counties of the State are represented in the sugar-beet analyses made during the past season. Brown county leads with 101 samples of beets,

> Kewaunee being second with 74 samples. Ten counties furnished 50 or more samples each. The highest average for the sugar in the juice, 11 samples analyzed, was obtained for Oconto County, namely, 15.48 per cent with a purity coefficient of 79.6, followed by Door County, which gave 15.11 per cent sugar in the juice, purity 77.4, as the average of 15 samples. The average sugar content of the juice of the beets was above 12 per cent in case of 49 counties, above 13 per cent in case of 26 counties, and above 14 per cent in case of 8 counties.
>
> *Adaptability of different parts of the State to sugar-beet culture.*—A close study of the results given in the preceding tables will be of interest, and is necessary in order to properly understand the situation of the question of sugar-beet culture in our State. The table indicates what an investigation continued through four growing seasons has revealed as to the adaptability of the soil in different parts of the State to the culture of this crop. In case of a few counties, especially the extreme northern ones, the number of analyses made is not sufficiently large to warrant our drawing definite conclusions as to the quality of beets there grown, but in the large majority of counties the number of analyses is ample to be considered a true representation of what beets grown in the respective counties will show when raised by farmers who have no special knowledge of the requirements of the sugar beet as to culture, soil, etc.
>
> If the averages of the sugar contents for the various counties, as given in the last table, be marked on a Wisconsin map, and the counties whose averages come, say, above 13 and above 14 per cent of sugar in the juice be shaded, it will at once be noticed that the counties producing the richest beets are those lying east and southeast of the Wisconsin River, and those in the northwestern corner of the State along the Mississippi and St. Croix rivers, from Buffalo County and north. The Lake Shore region is shown to be peculiarly well adapted to the culture of sugar beets; all counties producing beets with an average content of sugar in the juice above 14 per cent in the past season's analyses border on Lake Michigan or are adjacent to counties bordering on this lake.

Mr. Woll is also of the opinion that those soils of the State which have been derived from limestone are best suited to the growth of sugar beets. He makes the following comment in regard to the sugar content of the beets:

> *Sugar content of beets.*—The table shows that the average per cents of sugar in the juice for the years given were as follows: 1890-1892, 12.76 per cent; 1897, 12.67 per cent, or an average of 12.70 per cent for the years 1890-1897, the last figure being the mean of nearly 2,200 analyses. The usual minimum standard for beets adapted to factory purposes is 12 per cent sugar in the beet. Since beets contain about 95 per cent of juice, this will correspond to $\frac{12}{.95} = 12.63$ per cent of sugar in the juice. Our average therefore exceeds this minimum figure by a small fraction of 1 per cent.

The influence of the character of the soil upon the weight, sugar content, and purity of the beets is summarized by Mr. Woll in the following statements:

> In the sections of our State where exclusive grain raising has given way to diversified farming, dairying, stock raising, or market gardening, the land is usually in a good state of fertility, and a sufficient amount of barnyard manure is produced every year so that no artificial fertilizers need be purchased. But where grain raising is still continued as the sole reliance of the farmers, there is no hope for sugar-beet culture until the system of farming is changed, and the manure produced by the stock kept is carefully saved and applied, or commercial fertilizers are purchased for the beet fields.

Second method.—The second line of investigations conducted by the experiment station consisted in the establishment of substations in different parts of the State. As was mentioned in a previous part of this report, this is by far the most hopeful manner of conducting an agricultural survey of the State for the purpose of determining its suitability for the growth of sugar beets. In all, 33 farmers who took charge of this substation work made complete reports to the central station. The average expense per acre reported by 32 of these was $28.73. One report, showing an expense of $94.34 per acre, was excluded from the average. The average yield per acre, as reported from the 33 stations, was 29,850 pounds, or 14.9 tons of 2,000 pounds each per acre. This yield includes only 27 returns, since 6 of the substations failed to return the yield per acre. The lowest yield per acre reported was 6 tons, and the highest 24.8 tons. The average result of the analyses of the samples from the different substations is shown in the following table:

	Weight of beets.	Sugar in juice.	Purity coefficient.	Weight of beets.	Sugar in juice.	Purity coefficient.
	Pounds.	*Per cent.*	*Per cent.*	*Pounds.*	*Per cent.*	*Per cent.*
Average for 23 substations in southern half of State (30 and 31 samples, respectively)	1.17	13.58	80.0	1.79	15.35	79.0
Average for 13 substations in northern half of State (17 and 15 samples, respectively)	1.42	13.35	81.7	1.59	14.97	82.5
Average for 36 substations (47 and 46 samples, respectively)	1.26	13.49	80.6	1.72	15.22	80.2

For the first attempt at collecting data by a complete agricultural survey, the above results may be regarded as exceedingly encouraging. With larger experience on the part of the farmers in charge of the experiments, however, much more valuable and convincing data might be obtained.

Third method.—The third class of experiments conducted by the Wisconsin station consisted in investigations at the station farm itself. For the details of these experiments Bulletin 64 may be consulted. The following is a summary:

The field selected for the experiments was divided into two portions. The eastern half had been a meadow continuously since it came into cultivation up to 1895, when rape was grown thereon, followed by a crop of peas in 1896. The western half of the field had been plowed only once during the past twenty years, when it was cultivated in Indian corn. It had been pastured during the past ten years until 1896, when it was planted to rape and the rape eaten off by sheep. The beet crop did not do well on this field, the whole northwestern portion of it, after the 1st of August, showing no increase in the growth of the beets, the foliage turning yellow and the plants dying away to a large extent. The field was plowed 6 inches deep on May 7, and plowed again 12 inches deep on May 20. About four-fifths of it was subsoiled to a depth of 6 inches. The agricultural analytical data obtained from this field are given in the following table:

Yield of beets and of sugar per acre, main field.

No. of plat.	Name of seed.	Eastern half.				Western half.			
		Yield of beets from plat.	Yield of beets per acre.	Sugar in the beet.	Sugar per acre.	Yield of beets from plat.	Yield of beets per acre.	Sugar in the beet.	Sugar per acre.
		Pounds.	*Pounds.*	*Per ct.*	*Pounds.*	*Pounds.*	*Pounds.*	*Per ct.*	*Pounds.*
1	Kleinwanzlebener, Neb	3,422	24,010	12.72	3.059	2,874	25,030	15 80	3,959
2	Desprez, Men	2,826	22,060	11.71	2,543	3,122	30.230	13.71	4,144
3	Kleinwanzlebener, Agnew	3,053	21,450	10.96	2,352	2.301	32,120	15 17	4,873
4	Kleinwanzlebener, Hoerning	2,875	20,160	15.04	3,038	1,299	20,210	17.06	3,448
5	Vilmorin Improved	2,221	15,610	14.68	2,291	1,308	15,030	14.28	2,141
6	Vilmorin Kleinwanzlebener	2,473	17,380	10.65	1,850	2.728	23,770	14.98	3,561
7	Vilmorin French	2,485	17,460	11.26	1.966	2,701	23.540	13.58	3,196
8	Kleinwanzlebener, Floto*	2,258	15,860	14.24	2.259	1,472	12,820	14.05	1,801
9	Desprez White, No. 2*	2,081	14,620	10.95	1,602	1,429	12,460	14.38	1,790
10	Desprez White, No. 2 B*	2,108	14,810	15.05	2,228	1,408	12.270	11.71	1,436
11	Wernich's Kleinw., Floto*	2,111	14,840	15.65	2.320	1,236	10,760	13.62	1,467
12	Demesmay*	1,321	15,510	14.23	2,207	799	11,600	10.28	1.192
13	Kleinwanzlebener, Neb. (2)*	887	20,760	15.83	3,287	355	10,300	10.75	1,058
	Averages, etc	30,121	18,043	13.22	2,385	23,032	18,472	14.18	2,620

* Not included in average for western half.

The cost of cultivating this field is given as follows:

Cost of growing an acre of sugar beets.—A careful account was kept throughout the season of the labor done on the 3-acre beet field; valuing labor as previously given, we have the following summary:

Plowing and preparing the land	$12.42
Planting	1.70
Cultivating, hoeing, thinning and transplanting	51.63
Harvesting and placing in cellar	31.60
Total	97.35

This sum, $97.35, or $32.45 per acre, does not include the cost of seed or rent of land. It is nearly $4 higher than the corresponding figure obtained as the average for 28 substations; the greater cost with us is easily accounted for by the weedy condition of the western half of the field, as well as by the fact that the harvesting of our beets was a comparatively slow and difficult job, since the different lots and varieties had to be harvested and kept separately.

In addition to the work summarized above the station took part in the growth of high-grade beets on special plats under the supervision of the Department. The results of these experiments are given in another place.

WYOMING.

Thirty-four samples of beets grown in Wyoming were received at the Department of Agriculture for analysis. The mean weight of the beets received was 19 ounces, the mean content of sugar in the beet 17.2 per cent, and the mean purity 82.3. These data are exceptionally fine, and show that, in so far as the production of a crop is concerned, Wyoming will be able to compete with any State in the Union. The thermal conditions which prevail in the State are extremely irregular, the low valleys having warm and the high plateaus cool summers. It is evident that only on the plateaus, where the land is reasonably level, and where irrigation can be practiced, will it be possible to grow, with absolute certainty, a crop of beets of high saccharine strength.

Among the counties of Wyoming the two which furnish the most data are Converse and Big Horn. Converse County lies in the southeastern part of the State and Big Horn in the northwestern. In the beets from Converse County the average weight was 26 ounces, the mean content of sugar 17.8 per cent, and the mean coefficient of purity, 82.2. Big Horn County furnished six samples, of which the average weight was 20 ounces, the mean content of sugar 18.7 per cent, and the mean coefficient of purity 82.2.

When these analyses were made, showing such fine results, we wrote at once to the parties to see if we could not get a quantity of the beets for mothers in producing beet seed. The reply was made that they had all been frozen, and therefore no samples could be furnished. This reply to our inquiry indicates the chief difficulty to be encountered in Wyoming in introducing the beet industry, namely, the sudden advent of cold weather and the severity of the early winters in that locality. In Big Horn County some of the altitudes are 10,000 feet, and the whole county has a very great elevation. In the southeastern portion of the State the altitude generally reaches 7,000 feet. It is evident, therefore, that these high elevations give cool summers and favor the early advent of winter.

Another point to be considered is the mountainous character of the State, which, of course, precludes the possibility of culture over extensive areas. In low valleys protected by mountain ranges, if from 15,000 to 25,000 acres of land in a body could be secured, it seems probable that the industry of beet growing might be introduced with every probability of success. The temperature conditions, however, of October and November should be most carefully considered, as it would doubtless be necessary, even in the most favored valleys of Wyoming, to have the beets securely protected by the middle or end of November. This short harvesting season can not help but add a great deal to the cost of production, and hence must be taken into consideration.

In that part of the country also the question of the supply of water is a very important factor, and must not be lost sight of, as not only will water be required for the growing of crops, but also in immense quantities for manufacture.

The data at hand only permit us to study the composition of the beet itself, and surely Wyoming is to be congratulated on having produced, judged from the limited number of samples supplied, an excellent quality of beets.

VERMONT.

Only 8 samples of beets from Vermont were received at the Department of Agriculture, and these were of very high quality. The mean weight of the samples received was 22 ounces, the mean content of sugar in the beet 14.2 per cent, and the mean coefficient of purity, 84.1.

At the agricultural experiment station of Vermont 32 samples were received. The average weight of the beets received at the experiment station was 17 ounces, the mean percentage of sugar in the beet 16.3, and the mean purity 84.2. In reporting the results of the experiments the director of the station makes the following observations:

RESULTS OF EXPERIMENTS IN VERMONT.

One hundred persons guaranteed at the outset of the season to grow the crop and ship us samples. We had returns from twenty-seven. The remaining seventy-three, however, were not so much at fault as was the Weather Bureau. The weather throughout the State during the months of May, June, and July and the first part of August was execrable, there being several times the normal rainfall. In almost every case of not sending samples the report was that the crop was drowned out. It strikes me as somewhat doubtful whether the results obtained in the twenty-seven cases reported are truly representative of what might be expected under normal conditions of weather. The percentages of sugar certainly run quite high. I find that several of the growers sent their samples to Washington. I should be gratified, if it were possible, to receive the statement of the analyses, as we may wish to make some use of the sugar-beet data ourselves, which, as I understand, we are at liberty to do.

The majority of those who made a failure of the work this year expressed their desire to try again next year.

Of 32 beets analyzed at the agricultural experiment station of Vermont the number containing from 12 to 14 per cent of sugar was 2; the number containing from 12 to 14 per cent of sugar and weighing 16 ounces or over was 1; the number containing more than 14 per cent of sugar was 28; the number containing more than 14 per cent of sugar and weighing 16 ounces or more was 12.

It is seen from the above data that the only limitations upon the growing of beets in Vermont are the extent of the area suitable to the culture of the beets and the length of the growing season. It is evident, in so far as growth is concerned, that such a season as that of 1897 is capable of producing beets of the highest grade, but the growing season includes properly the season of harvest and preservation of the beets. The high northern latitude of Vermont and the early and severe winters must be taken into consideration in this particular. Vermont is also a mountainous country, and the areas of level land are not proportionately so great as in most of the States which have been considered for beet growing. Where bodies of from 15,000 to 25,000 acres of level and fertile land can be found with the autumnal conditions favorable for the harvest and preservation of the beets, there is no reason to doubt the possibility of successfully establishing the beet-sugar industry.

INFLUENCE OF TEMPERATURE ON THE QUALITY OF SUGAR BEETS.

The influence of temperature and other climatic conditions upon the growth of beets is discussed under the head of special experiments in growing beets from high-grade seeds. It will be interesting, however, to compare the deductions from that discussion with those from data obtained from certain parts of the country where favorable conditions exist for making this comparison. The States of Ohio, Indiana, and Illinois are situated in a peculiarly favorable manner for a study of this kind. Each of these States has a portion of its area in the theoretical thermal belt and a large portion of its area outside of that belt. In each of these States, therefore, the data received from the various counties were classified into three portions, namely, the northern, the central, and the southern belts.

The following is a tabulation of the data from each one of these sections in the three States:

Relation of latitude to development of sugar content.

	Northern belt.			Central belt.			Southern belt.		
	Average weight of beets.	Sugar in beets.	Purity coefficient.	Average weight of beets.	Sugar in beets.	Purity coefficient.	Average weight of beets.	Sugar in beets.	Purity coefficient.
	Ounces.	*Per ct.*		*Ounces.*	*Per ct.*		*Ounces.*	*Per ct.*	
Ohio	29.4	13.6	79.4	32.6	13.2	78.0	35.0	12.2	75.3
Indiana	18.9	13.3	81.9	18.5	12.9	80.7	14.2	10.7	78.0
Illinois	22.0	13.2	79.3	20.0	11.5	75.4	19.0	11.1	74.7

The data in the above table have a peculiar value in establishing, by experimental results, the validity of the scheme employed in the construction of the theoretical thermal belt suitable to the growing of beets. In every one of the States mentioned there is a gradual deterioration in the quality of the beet, both as respects its sugar content and its purity, in passing from the northern to the southern belt of the State. It may be said that the difference between the two extreme areas is not very great, and that for this reason it would be advisable to establish factories indiscriminately in one or the other of the belts, according to more or less favorable local conditions, aside from the sugar content of the beet. The fallacy of this statement, however, will be evident to anyone who studies carefully the conditions of manufacture. An increase of 1 per cent in the sugar content of the beet means an increase of 20 pounds per ton in the amount of sugar manufactured, without any corresponding increase in the expense of manufacture. In other words, the cost of extracting the sugar from a ton of beets which would yield 180 pounds would be just as great as that attending a ton of beets which would yield 200 pounds of sugar. But the additional value of the 20 pounds of sugar manufactured might in many instances determine whether the business would be conducted at a profit or a loss. The above assumption is true on the supposition that the coefficient of purity remains the same in each case. When we consider in addition to the loss of the sugar, the depreciation in the purity of the juice, the discrepancy between the sections becomes all the greater. Not only is the loss attending the lower sugar content of the beet to be considered, but also the additional loss which is coupled with the lower purity. In other words, a ton of beets with a coefficient of purity of 80, which would yield 200 pounds of sugar by the ordinary processes of manufacture, would yield very much less than this if the purity coefficient should fall to 76, and would yield very much more if it should rise to 85. The data obtained in the above table afford convincing proof of the fact that it is not safe to push the manufacture of beet sugar too far south of the theoretical thermal belt, unless the depreciation in the sugar content and purity of the beet is compensated for by some remarkable local factors, in the way of cheapness of manufacture, which will make good the loss due to the low content of sugar and the low purity of the juice. These figures, obtained in this miscellaneous way, are fully corroborated by the careful experimental data obtained in the culture of high-grade beets at the six stations which are mentioned in another place. From exactly the same seeds, planted in exactly the same way and cultivated in the same manner, exceptionally high grade beets of fine sugar content and high purity were obtained from the New York station, good beets were grown at the Wisconsin station, fairly good beets at the Iowa station, beets with a fairly good content of sugar but diminutive in size on account of the drought at the Indiana station, beets of good size and very low content of sugar at the Kentucky station, beets of only minimum content of sugar and very small size at the Tennessee station. These results are such as should be studied carefully by intending investors who desire to place their money where the certainty of return is the greatest. With such magnificent areas open to cultivation as are found in the States of New York, northwestern Pennsylvania, northern Ohio, northern Indiana, and southern Michigan, it would not be wise for men of capital to select localities which the figures at hand indicate are less favorable to the production of high-grade beets. The data which have been obtained from New York and from Michigan indicate that with the best principles of culture, with good fertilization and skilled oversight, beets can be grown over wide areas fully equal in sugar-producing power to those which are grown by the skilled farmers of Germany. On the other hand, it is quite certain that if the area of culture be pushed to the south, so as to fall entirely without the limits of the thermal belt, the same fertility of soil, the same fertilization, and the same care in culture will produce beets less rich in sugar, with a lower purity, and yielding less sugar per ton than those grown in the localities first mentioned.

As to how far the successful growth of the sugar-beet industry can be pushed north of the limit of 69°, it may be said that the only condition to be considered in this matter is the possibility of producing and ripening a crop and harvesting it before the rigors of winter set in. The culture of the sugar beet may be very successfully practiced in localities where the mean summer temperature falls even as low as 64°, provided the latitude is far enough north to get sufficient sunshine to mature the beets before the frosts of autumn. If the autumn be mild and merge gradually into winter, the limit of successful culture will be found where the freezing weather of winter cuts short the time required for the harvesting and siloing of the crop of beets. In the light of the data at present available, therefore, the southern limit of the sugar-beet belt may be regarded as the isotherm of 71° for the three summer months, occasionally pushing 50, 75, or even more miles south of this line, where exceptional conditions of soil and manufacturing facilities are presented. The facts of the case, however, warrant the statement that the safer plan will be not to push south of the isotherm of 71° so long as equally favorable conditions of soil and manufacture are obtainable north of this line of demarcation. It is deemed wise to dwell particularly upon this subject, because of the fact that so many people living south of the isotherm of 71° are vitally interested in this matter and so eager to have the industry established in the neighborhoods in which they live. The conclusions which have been drawn are not meant to discourage experimental work in areas widely remote from those mentioned. It is only just, however, to call attention to the fact that investments of large amounts of capital which result disastrously do more to deter the successful establishment of an industry than a much larger number of successful investments favor it. For instance, in the State of Wisconsin we have an illustration of the financial failure of an attempt to manufacture beet sugar, and as a result of this failure it will be difficult to induce capital to look for investment in Wisconsin in the sugar-beet industry, although the conditions in that State are exceedingly favorable to success. Had it not been for the failure of the factory projected at Menominee Falls, it is quite certain that other capital would be invested in the State at the present time, and instead of the industry being in a stagnant condition it would be advancing on the road toward success. It is extremely important that no mistakes be made from a financial point of view, and that every precaution to avoid these mistakes be observed. When subsequent experimentation shall have demonstrated that there are areas outside, and especially south of the theoretical belt, equally as well suited to the growth of beets sufficiently rich in sugar as those which have been mentioned, it will be time enough to ask capital to seek investment in those localities.

SUGAR BEETS AS CATTLE FOOD.

Thousands of farmers in various parts of the country are growing beets in an experimental way and have no opportunity to dispose of their product to sugar factories. These farmers may, nevertheless, find the growing of small quantities of sugar beets profitable by using the product for cattle food. Following is an analysis lately made in this laboratory of a sample of sugar beets received from a locality such as is mentioned above:

Composition of fresh beet pulp.

	Fresh pulp.	Dry matter.
	Per cent.	*Per cent.*
Moisture	73.87	....
Fiber (crude)	1.53	5.89
Ash	1.35	5.18
Ether extract (fat)	.11	.42
Proteids	2.21	8.47
Sugar and other carbohydrates	20.93	80.04
	100.00	100.00

The sample in question contained 73.87 per cent of water and 26.13 per cent of dry matter. The analyses of hundreds of samples of beets in this laboratory show that the average content of fiber, usually called "marc," is about 5 per cent. In the process of analysis all this marc is dissolved except that which is entered above as crude fiber, namely, 1.53 per cent. The difference between this and the 5 per cent average content of marc, namely, 3.47 per cent, shows the quantity of carbohydrate matter not sugar contained in the 20.93 per cent of total sugars and carbohydrates. The quantity of sugar in the sample analyzed was, therefore, 17.46 per cent. Practically all, however, of the carbohydrates, except those represented by the crude fiber, are digestible, so that the soluble marc has practically the same food value as the sugar itself. The ratio of the proteid matter to the digestible carbohydrates plus fat multiplied by 2¼, is 9.59. This ratio shows that the food is particularly a fattening one, and could be used to great advantage in preparing fat stock for market. The analysis also indicates that the food, to secure the best results for all-round sustenance, should be fed with some highly nitrogenous ration in order to secure a smaller ratio between the two groups of nutrients. It may be said with perfect confidence that it will be far more profitable for the farmer to grow sugar beets at 12 tons per acre for cattle food than other root crops, such as turnips and ruta-bagas, which will yield double that quantity per acre. The food value of these crops does not depend upon the gross tonnage, but upon the actual nutrients which they contain. Sugar beets contain, as is seen, over 20 per cent of their weight of actual nutrients, while turnips and radishes may contain only from 6 to 12 per cent.

USE OF BEET PULPS FOR CATTLE FOOD.

The residue from beet factories, in the form of the beet pulp, is also a valuable cattle food. In this country no carefully controlled feeding experiments have been conducted with this material, but the question has been studied most thoroughly in Europe, and the data obtained can be used for our guidance. There is practically no difference in chemical composition between the beet pulps obtained in

Europe and in this country, so that the deductions to be drawn from the feeding experiments in that country can be applied with perfect safety to similar work here. At many of the factories in this country practical feeding tests have been made, and with favorable results. Having heard that successful experiments in feeding cattle and sheep had been conducted at the factory of the Pecos Valley Beet Sugar Company, I addressed a letter to the manager of that factory, and received the following reply:

EDDY, N. MEX., *February 21, 1898.*

DEAR SIR: I have your letter of the 14th. Shortly before the close of our campaign, Mr. A. J. Crawford, a large sheep owner of this section, looked into the question of feeding beet pulp to sheep, and finally decided to try a bunch of 500 lambs as an experiment. These lambs were the culls of his flock, and when brought to the feeding pens at the factory were in very poor condition. In a few days they took to the pulp very readily, and are now eating 7 to 10 pounds of pulp per day each, with sufficient hay (alfalfa) as roughening. They have picked up wonderfully during the time they have been here, and Mr. Crawford tells me that they are now the best looking of any he has. He is so well satisfied with the result of his experiment that about a week ago he brought in 2,000 ewes with the intention of feeding them on the pulp during the lambing season. You, of course, are aware that the pulp is a great milk producer, and by feeding it Mr. Crawford will be able to carry both ewes and lambs through in good shape until the grass comes, and, of course, thereby prevent the loss which he would otherwise have to stand of the many ewes and lambs which would die on the range.

When the lambing season is over and we see how the sheep come through I shall be glad to write you fully. Mr. Crawford is anxious to make a contract for all our next year's pulp, and I have no doubt that the feeding of sheep on pulp in this valley will become quite an industry.

Yours, truly,

A. S. GOETZ,
General Manager.

Mr. H. W. WILEY,
Dirision of Chemistry, Washington, D. C.

It is evident from the above that these practical experiments in feeding, although not controlled by actual chemical analyses, have been eminently successful, and it is not at all unlikely that within a few years our beet factories will be able to contract in advance for all the pulp which they can possibly produce. To illustrate more clearly the value of the pulp and its value for feeding purposes, the following extracts, taken from standard European authorities, are published:

DIFFUSION PULPS OR EXHAUSTED COSSETTES.

The following table contains an average of analyses made by Messrs. Vivien, Lucas, Duvin, Durot, and Dupont as a commission of experts in France:

	Fresh pulp.	Dry material.
	Per cent.	*Per cent.*
Moisture	89.00	....
Nitrogenous matter	.92	8.43
Digestible carbohydrates	6.52	59.76
Indigestible carbohydrates	1.98	18.15
Fat	.09	.83
Mineral matter	1.40	12.83
	100.00	100.00
Solid matter	10.91	....

FEEDING EXPERIMENTS WITH BEET PULP.

Extensive tests in feeding pulps have been made at the Francières sugar house of M. Gallois. The following animals were used: (1) Beef cattle, (2) oxen, (3) milch cows, (4) sheep, (5) ewes. Before beginning the tests, these animals were all gradually accustomed to the change from their customary ration to that of diffusion pulp.

(*a*) *Beef cattle.*—Twelve beeves each received every day, in three meals, 52.26 kilograms (115 lbs.) of diffusion pulps, mixed with 3 kilograms of linseed oil cake and 3 kilograms (6.6 lbs.) of chopped alfalfa. Their weight increased an average of 1.004 kilos (2.214 lbs.) per day. If we consider the value of the meat as 0.95 franc ($0.19), that of the oil cake 0.25 franc ($0.05), and that of the alfalfa 0.08 franc ($0.016) per kilogram (2.2 lbs.), we find that the feeding value of the diffusion pulp was 6.58 francs ($1.316) per 1,000 kilograms (2,205 lbs.).

(*b*) *Oxen.*—Four oxen each received the following ration per day: 57.5 kilograms (126.8 lbs.) of diffusion pulp mixed with 5 kilograms (12 lbs.) of alfalfa and 1 kilogram (2.2 lbs.) of linseed-oil cake. These cattle decreased somewhat in weight in the first fifteen days, and did less than the usual amount of work, but in the second fifteen days they had entirely recovered. The trial continued two and a half months. In making a calculation analagous to that above, the value of the diffusion pulp was 4.78 francs ($0.956) per 1,000 kilograms (2,205 lbs.).

(*c*) *Milch cows.*—The test with milch cows lasted thirty days. Two cows were employed—one Flemish and the other Dutch. Before the tests the cattle were fed on dry alfalfa with a small quantity of beet pulps produced by the hydraulic-press method. The cows were each given, per day, 45 kilograms (99.2 lbs.) of diffusion pulp with 2 kilograms (4.4 lbs.) of alfalfa. The tests demonstrated that the diffusion pulp is more advantageous as regards lactation than in the production of flesh.

Cows fed on diffusion pulps.

Date.	Cream per 100 cc. of milk.	
	Cow No. 1.	Cow No. 2.
April 27	8.00	7.00
May 1	7.50	8.00
May 12	7.50	8.00
May 19	7.50	8.00

From these tests it was shown that the milk of the cows fed from diffusion pulp contained an average of 7.68 per cent of cream. The butter produced from this milk did not have the peculiar disagreeable odor which is present in that from cows fed on press pulps.

(*d*) *Sheep.*—In this test twenty merino sheep were fed on diffusion pulp. The following table shows the result of this test and the rations fed per animal:

	Kilos.		
Weight:			
April 4	948	=2,085.6	pounds.
April 26	1,008	=2,217.6	pounds.
Total increase	60	= 132.0	pounds.
Increase per sheep per day	0.137	= .3	pounds.
Average rations per head:			
Pulp	5.4	= 11.88	pounds.
Linseed-oil cake	.2	= .44	pounds.
Chopped alfalfa	.5	= 1.10	pounds.

It was not necessary to make other additions to the diffusion pulp, since the sheep ate it with avidity. With the aid of these figures we may calculate the value of the pulp as follows:

The sheep gained per day 0.137 kilogram (.3 lb.) in meat, which at 1 franc ($0.20) per kilo (2.2 lbs.) equals 0.137 franc ($0.027). They consumed a ration, exclusive of the pulp, costing 0.09 franc, therefore the value of the 5.4 kilos (11.9 lbs.) of diffusion pulp was 0.047 ($0.01), or 8.70 francs ($1.74) per 1,000 kilograms (2,205 lbs.).

Experiments made with ewes.—The ewes were obtained from a flock from which the lambs had just been separated. In feeding the ewes, to which a somewhat larger ration was given, the value of the pulp was found to be 6.03 francs ($1.206) per 1,000 kilograms (2,205 lbs.). Taking all of these elements into account, the experts estimated definitely the value of 1,000 kilograms (2,205 lbs.) of diffusion pulp to be 5.55 francs ($1.11). They also demonstrated that diffusion pulps keep perfectly.

Not taking into account questions of transportation, etc., the value of diffusion pulp was estimated at 6.10 francs ($1.22) per 1,000 kilograms (2,205 lbs.). Basing a conclusion upon the chemical analysis of the pulp, a value of 6.44 francs ($1.288) was obtained, as compared with the 6.10 francs ($1.22) per 1,000 kilograms (2,205 lbs.) given by experiments.

EXPERIMENTS BY ANDOUARD AND DÉZAUNAI.

(Sucrerie Belge, Vol. 12, No. 7.)

In tests in feeding diffusion pulp to milch cows this pulp was given in a ration, first of 27 kilograms (59.5 lbs.) and later 55 kilograms (121.3 lbs.) per day, and produced immediately an increase of approximately 32 per cent in the yield of milk. It appeared, however, to be without influence on the richness of the milk in casein and mineral matter, but produced an increase in the yield of butter of 12.4 per cent, and in that of the sugar of 24.63 per cent over the previous proportions of these constituents. It, however, gave the milk a less agreeable taste and a certain predisposition to an acid fermentation. The butter, therefore, would probably not be of excellent quality.

*Analyses of diffusion pulps before ensilage.**

Constituents.	Maercker.	Kühn.
	Per cent.	*Per cent.*
Water	89.77	88.9
Dry matter	10.23	11.1
Ash	.58	.9
Fat	.05	.1
Crude fiber	2.39	2.5
Crude protein	.89	.9
Nitrogen-free extract	6.32	6.7

*Diffusion pulps after having been stored in the silos.**

Constituents.	Maercker.	Kühn.
	Per cent.	*Per cent.*
Water	88.52	87.5
Dry matter	11.48	12.5
Ash	1.09	.9
Fat	.11	.1
Crude fiber	2.80	3.0
Crude protein	1.07	1.2
Nitrogen-free extract	6.41	7.3

* Sachs' Revue Universelle des Progrès de la Fabrication du Sucre, 1, 428.

Analysis of diffusion pulps, by Pellet.

Constituents.	Pressed pulp.	Dry material.
	Per cent.	*Per cent.*
Water	88.06	....
Nitrogenous matter	.84	7.04
Digestible carbohydrates	7.30	61.14
Indigestible carbohydrates	2.46	20.60
Fat	.06	.50
Soluble mineral matter	.43	3.60
Insoluble mineral matter	.85	7.12
	100.00	100.00
Dry matter	11.94	....

Maercker (Sucrerie Belge, vol. 11, page 464) determined that siloed pulps, in addition to losing water, also lost a considerable portion of their dry matter. This is shown in the following statement of the analysis of pulps which were siloed for five months, in which time they lost the following percentages:

Thirty-seven and eight-tenths of nitrogen free extract, 25.5 of nitrogenous matter and 29.6 of the fiber which they contained: The pulps gained, on the contrary, in fat, owing to the lactic and butyric fermentations. The losses were due to decomposition, and not to entrainment in the moisture lost.

*Analyses of diffusion pulp, by Vivien.**

Constituents.	Pressed pulp.	Dry material
	Per cent.	*Per cent*
Digestible proteids (nitrogen X 6.25)	0.64	7.73
Indigestible proteids (amid nitrogen X 9)	.04	.48
Nitrate of potassium	.05	.60
Digestible carbohydrates	4.07	49.15
Cellulose and indigestible carbohydrates	1.92	23.19
Fat	.05	.60
Sugar	.54	6.52
Assimilable mineral matter	.35	4.23
Indigestible mineral matter	.61	7.37
Water	91.72	....
	100.00	100.00

*Analyses of diffusion pulp, by Pellet.**

Constituents.	Pressed pulp.	Dry material.
	Per cent.	*Per cent.*
Water	88.88	....
Organic matter	9.95	89.50
Soluble inorganic matter	.57	5.13
Insoluble inorganic matter	.60	5.40
	100.00	100.00
Acidity (expressed as acetic acid)	1.01	9.08
Total nitrogen	.147	1.32
Insoluble nitrogen (at the boiling point of water)	.111	....

* Sachs' Revue Universelle des Progrès de la Fabrication du sucre, 1, 429.

The pulps diminished in weight in the silos, the diffusion pulps losing 6 per cent per month. At the same time there was a diminution in the weight of the dry matter, approximately 1 per cent of the diffusion pulp.

It is evident from the above data that the value of the pulp from beet-sugar factories, especially in thickly settled countries and in those regions where the dairy interests are prominent, will prove of no inconsiderable advantage in the successful introduction of the beet sugar industry and its rapid advancement. Beet pulps form a wholesome and nutritious, though a somewhat poorly balanced ration. Their chief nutriment is found in the carbohydrates, composing the marc of the beet and including the unextracted sugar, and in the proteid nitrogenous matters, and a large percentage of these is easily digested. While beet pulp is not suitable for the entire food of the animal, it can be made a principal part thereof, varying its proportions with the nature of the effect desired to be produced. Experience has shown that it is especially relished by dairy cattle, produces an abundant supply of milk, and where properly preserved and fed, it can be used in great abundance without imparting to the milk, butter, or cheese any unpleasant flavor.

SUMMARY OF DATA COLLECTED IN PREVIOUS YEARS.

In order to present data covering as wide a field as possible, and including the experiments of several seasons, the following table has

been compiled from the reports of the Division of Chemistry and from the bulletins of the various State experiment stations:

Analyses of sugar beets grown in various States.

[A compilation of the analytical data obtained at the various State experiment stations for the years 1888 to 1897, inclusive, and at the United States Department of Agriculture for the years 1884 to 1897, inclusive.]

State.	Year.	Analyses by the United States Department of Agriculture.				Analyses by the State experiment stations.			
		Number of samples.	Average weight.	Sugar in beet.	Purity coefficient.	Number of samples.	Average weight.	Sugar in beet.	Purity coefficient.
			Ounces.	*Per ct.*			*Ounces.*	*Per ct.*	
Alabama	1893	......	......	5.9	66.7	......	......	......	......
Arizona	1891	2	51	7.7	56.9	......	......	......	......
	1897	7	23	9.3	70.4	157	......	*a* 8.1	61.8
Average	......	9	29	9.0	67.4	157	......	8.1	61.8
Arkansas	1891	2	40	6.4	58.8	......	......	......	......
	1892	3	12	9.4	64.7	......	......	......	......
	1897	2	18	11.3	71.5	......	......	......	......
Average	......	7	22	9.1	65.0	......	......	......	......
California	1884	71	19	13.7	85.3	......	......	......	......
	1888	......	......	......	......	5	......	10.7	......
	1889	......	......	......	......	14	19	12.1	77.7
	1890	4	13	14.7	84.6	18	17	10.7	73.0
	1891	8	48	11.1	75.8	......	......	*b* 13.0	
	1892	4	14	14.7	77.6	......	......	*b* 14.0	
	1893	......	......	......	......	......	......	*b* 14.0	
	1894	......	......	......	......	......	......	*b* 15.0	
	1895	......	......	......	......	......	......	*b* 15.0	
	1896	......	......	......	......	......	......	*b* 14.0	
	1897	1	26	16.8	......	......	......	......	......
Average	......	88	21	13.6	85.3	37	18	11.2	75.1
Colorado	1888	......	......	......	......	......	......	9.9	......
	1889	......	......	......	......	37	......	10.2	......
	1890	29	20	12.5	76.1	73	25	11.0	83.0
	1891	51	26	13.1	76.1	4	......	* 13.5	79.3
	1892	170	18	14.8	81.7	16	......	* 13.8	80.6
	1893	18	17	13.2	74.9	......	......	......	......
	1897	174	20	13.6	76.7	12	......	14.3	79.7
Average	......	442	20	13.9	78.4	142	25	11.5	82.1
Connecticut	1890	2	14	9.7	76.1	......	......	......	......
	1891	5	27	10.8	77.3	......	......	......	......
Average	......	7	23	10.5	77.0	......	......	......	......
Georgia	1891	2	12	11.1	64.9	......	......	......	......
Idaho	1890	1	4	8.0	68.3	......	......	......	......
	1891	1	15	12.7	74.9	......	......	......	......
	1892	2	34	14.7	79.1	......	......	......	......
	1893	2	78	10.2	76.2	......	......	......	......
	1894	......	......	......	......	192	......	13.7	76.1
	1895	......	......	......	......	342	......	15.2	79.9
	1896	......	......	......	......	60	......	14.2	77.3
	1897	7	21	15.5	79.4	41	......	15.2	87.6
Average	......	13	30	13.8	77.6	635	......	14.6	80.2

* The sign * indicates that the number given is 0.95× per cent of sugar reported since it was doubtful whether the per cent of sugar was expressed in terms of the weight of the juice or that of the beet, though probably the former.

a Analyses of Kleinwanzlebener only show: 32 samples, sugar 11.8, purity 73.6.

b From report made on the total crop by the Chino Valley Beet Sugar Company.

Analyses of sugar beets grown in various States—Continued.

State.	Year.	Analyses by the United States Department of Agriculture.				Analyses by the State experiment stations.			
		Number of samples.	Average weight.	Sugar in beet.	Purity coefficient.	Number of samples.	Average weight.	Sugar in beet.	Purity coefficient.
			Ounces.	*Per ct*			*Ounces.*	*Per ct.*	
Illinois	1890	8	31	10.8	72.1	......	......	......	......
	1891	36	32	11.7	76.4	......	......	......	......
	1892	59	15	10.9	75.2	......	......	......	......
	1897	32	17	13.1	75.5	312	20	11.9	76.4
Average	......	135	21	11.6	75.4	312	20	11.9	76.4
Indiana	1888	......	......	......	......	5	......	12.2	......
	1889	......	......	......	......	10	......	11.9	......
	1890	56	23	10.7	72.7	26	7	9.1	......
	1891	77	27	11.6	76.9	131	[a] 20	12.0	78.8
	1892	57	14	11.2	72.5	95	12	11.1	76.8
	1893	4	10	10.7	73.1	49	12	11.8	79.3
	1894	......	......	......	......	84	25	11.8	78.8
	1897	103	14	13.1	78.9	205	18	12.0	80.7
Average	......	297	19	11.9	75.9	605	17	11.7	79.2
Indian Territory	1891	1	27	11.6	76.9	......	......	......	......
Iowa	1888	......	......	......	......	4	17	11.9	76.5
	1889	......	......	......	......	12	34	9.9	64.9
	1890	30	22	11.8	74.5	34	33	10.7	71.4
	1891	321	30	11.8	75.7	503	16	12.1	74.0
	1892	30	24	10.9	76.2	404	21	11.6	72.9
	1893	7	17	12.8	75.8	563	19	11.9	76.1
	1894	......	......	......	......	150	19	11.5	74.9
	1897	130	18	13.3	73.7	642	19	12.4	76.6
Average	......	518	26	12.1	75.2	2,312	19	12.0	75.0
Kansas	1889	......	......	......	......	7	......	8.9	69.7
	1890	22	32	8.3	69.3	16	31	7.9	......
	1891	36	33	10.7	68.2	183	19	9.6	70.6
	1892	22	25	11.1	74.2	115	21	10.2	73.4
	1893	1	......	14.3	72.8	22	21	10.1	71.8
	1897	41	27	11.4	73.8	158	17	11.9	77.0
Average	......	122	29	10.6	71.4	501	19	10.4	73.4
Kentucky	1891	3	34	9.1	63.7	......	......	......	......
	1892	4	13	8.9	77.2	......	......	......	......
	1897	6	16	11.9	71.5	......	......	......	......
Average	......	13	19	10.3	72.2	......	......	......	......
Louisiana	1893	3	12	8.9	68.3	......	......	......	......
Maryland	1890	83	15	12.2	79.8	5	10	12.2	79.7
	1891	2	16	7.4	68.5	......	......	......	......
	1897	29	19	11.4	79.1	......	......	......	......
Average	......	114	16	11.9	79.1	5	10	12.2	79.7
Massachusetts	1889	......	......	......	......	10	......	12.2	......
	1890	6	16	12.0	82.8	6	17	13.4	[b] 77.1
	1891	......	......	......	......	6	17	13.4	78.1
Average	......	6	16	12.0	82.8	22	17	12.8	77.6
Michigan	1889	......	......	......	......	6	[c] 19	12.6	......
	1890	30	31	12.0	78.4	......	......	......	......
	1891	50	32	12.6	78.0	229	......	13.3	86.2
	1892	71	19	14.1	83.4	......	......	......	......
	1893	88	15	13.3	82.1	......	......	......	......
	1897	450	22	14.7	81.1	465	27	16.4	84.0
Average	......	689	22	14.2	81.1	700	27	15.5	84.7

[a] Average weight of 71 samples.

[b] Purity of but 1 sample.

[c] Average weight of 2 samples.

Analyses of sugar beets grown in various States—Continued.

State.	Analyses by the United States Department of Agriculture.					Analyses by the State experiment stations.			
	Year.	Number of samples.	Average weight.	Sugar in beet.	Purity coefficient.	Number of samples.	Average weight.	Sugar in beet.	Purity coefficient.
			Ounces.	*Per ct.*			*Ounces.*	*Per ct.*	
Minnesota	1890	107	30	11.8	75.2	55	....	*12.3	76.5
	1891	41	29	12.4	75.7	467	*a*23	*13.0	79.7
	1892	22	29	12.2	78.1	180	17	14.3	85.5
	1893	7	60	10.8	70.8	....	....	....	....
	1897	49	24	11.0	79.2	143	17	13.1	81.8
Average	......	226	29	11.7	76.3	845	19	13.2	81.1
Missouri	1890	2	21	8.4	66.7	5	17	13.4	....
	1891	67	20	10.4	62.4	59	28	9.3	67.3
	1892	13	33	8.1	63.4	....	....	....	....
	1897	324	20	11.7	73.5	304	26	10.6	71.0
Average	......	406	20	11.4	71.6	368	26	10.4	70.4
Montana	1891	35	25	13.2	76.8	....	....	....	....
	1892	6	22	10.9	72.8	....	....	....	....
	1893	2	15	14.3	75.0	....	....	....	....
	1897	4	20	14.4	77.8	70	23	14.7	77.0
Average	......	47	24	13.1	76.3	70	23	14.7	77.0
Nebraska	1888	....	....	....	....	9	....	12.7	....
	1889	....	....	....	....	159	46	10.3	54.5
	1890	269	20	11.8	71.9	462	17	*12.3	73.9
	1891	62	35	11.7	75.3	218	*b*23	12.8	77.9
	1892	27	21	14.2	79.3	98	17	9.8	72.4
	1893	8	17	10.1	69.7	(*c*)	....	11.3	77.0
	1895	....	....	....	....	637	....	12.1	76.9
	1897	13	29	12.9	76.9	106	....	11.7	75.0
Average	......	379	23	12.0	73.1	1,689	22	11.9	73.7
Nevada	1891	18	11	17.2	88.0	222	25	12.5	76.9
	1892	81	13	15.9	83.4	221	18	14.8	80.8
	1893	....	....	....	....	51	20	13.6	80.8
	1894	....	....	....	....	....	....	....	....
	1895	....	....	....	....	176	....	13.1	*d*77.8
	1896	....	....	....	....	....	....	....	....
	1897	21	18	18.3	81.4	10	19	18.9	....
Average	......	120	14	16.5	83.7	680	21	13.6	78.7
New Hampshire	1891	1	19	11.6	80.0	....	....	....	....
New Jersey	1891	1	17	7.3	70.8	....	....	....	....
	1893	....	....	....	....	8	....	11.7	76.2
	1897	31	16	14.2	81.4	....	....	....	....
Average	......	32	16	14.0	81.1	8	....	11.7	76.2
New Mexico	1891	17	28	13.8	74.8	....	....	....	....
	1892	29	19	15.3	83.2	3	....	*17.0	....
	1897	3	13	17.2	82.0	219	26	13.2	....
Average	......	49	22	14.9	80.2	222	26	13.3	....

* The sign * indicates that the number given is 0.95× per cent of sugar reported since it was doubtful whether the per cent of sugar was expressed in terms of the weight of the juice or that of the beet, though probably the former.

a Average weight of 229 samples.

b Average weight of 88 samples.

c Analyses reported by the Standard Cattle Company.

d Averages for 1893 to 1896, inclusive.

Analgses of sugar beets grown in various States—Continued.

State.	Year.	Analyses by the United States Department of Agriculture.				Analyses by the State experiment stations.			
		Number of samples.	Average weight.	Sugar in beet.	Purity coefficient.	Number of samples.	Average weight.	Sugar in beet.	Purity coefficient.
			Ounces.	*Per ct.*			*Ounces.*	*Per ct.*	
New York	1889	....	....	....	....	6	....	9.9	....
	1890	10	15	12.1	78.0	....	....	....	....
	1891	4	32	11.6	76.8	....	....	....	....
	1892	8	22	15.4	85.9	....	....	....	....
	1893	....	....	....	....	29	38	12.9	....
	1897	225	21	15.0	82.4	562	*a* 16	15.9	83.2
Average	......	247	21	14.8	82.2	591	20	15.7	83.2
North Carolina	1892	4	4	9.0	73.4	....	....	....	....
	1893	....	....	4.1	52.1	....	....	....	....
	1897	7	23	9.1	75.3	....	....	....	....
Average	......	11	16	9.1	74.6	....	....	....	....
North Dakota	1890	24	25	13.4	71.2	9	....	13.8	....
	1891	11	23	11.8	73.2	129	29	10.9	73.9
	1892	11	24	12.9	76.5	....	....	....	....
	1893	2	27	14.0	80.7	....	....	....	....
	1897	4	28	10.5	81.2	....	....	....	....
Average	......	52	25	12.8	73.9	138	29	11.1	73.9
Ohio	1890	15	26	9.8	76.0	....	....	....	....
	1891	66	31	11.3	73.5	24	....	9.8	....
	1892	102	17	14.2	80.2	....	....	....	....
	1897	68	22	13.8	79.1	554	31	13.3	78.7
Average	......	251	23	13.1	77.9	578	31	13.2	78.7
Oklahoma	1891	1	48	6.4	53.3	....	....	....	....
	1897	1	10	11.8	72.5	21	....	11.4	65.3
Average	......	2	29	9.1	62.9	21	....	11.4	65.3
Oregon	1890	2	20	15.1	73.4	37	*b* 26	11.2	....
	1891	35	34	12.7	81.1	98	22	12.6	78.4
	1892	12	19	14.2	80.2	65	27	14.4	82.7
	1803	....	....	....	....	....	....	....	....
	1894	....	....	....	....	....	....	....	....
	1895	....	....	....	....	23	....	14.3	*c* 89.8
	1896	....	....	....	....	....	....	....	....
Average	......	49	30	13.2	80.6	223	24	13.1	81.3
Pennsylvania	1890	10	27	8.0	73.8	....	....	....	....
	1891	7	22	13.3	78.7	....	....	....	....
	1892	8	13	10.8	75.8	....	....	....	....
	1893	1	....	11.0	78.9	....	....	....	....
	1897	59	18	13.8	79.5	....	....	....	....
Average	......	85	19	12.8	78.4	....	....	....	....
Rhode Island	1897	2	21	11.9	74.2	....	....	....	....
South Carolina	1892	....	....	....	....	3	19	5.8	54.7
	1893	....	....	....	....	15	15	4.9	....
	1894	....	....	....	....	71	23	5.9	....
	1897	13	17	9.9	79.9	....	....	....	....
Average	......	13	17	9.9	79.9	89	22	5.7	54.7

a Average weight of 137 samples.
b Average weight of 2 samples.
c Averages for 1893 to 1896, inclusive.

Analyses of sugar beets grown in various States—Continued.

State.	Year.	Analyses by the United States Department of Agriculture.				Analyses by the State experiment stations.			
		Number of samples.	Average weight.	Sugar in beet.	Purity coefficient.	Number of samples.	Average weight.	Sugar in beet.	Purity coefficient.
			Ounces.	*Per ct.*			*Ounces.*	*Per ct.*	
South Dakota	1889	....	....	....	....	17	....	9.1	....
	1890	21	20	13.1	78.6	58	....	14.2	74.7
	1891	202	22	12.5	75.3	1,264	25	11.9	73.3
	1892	67	20	13.1	75.5	680	19	14.2	80.7
	1897	5	17	15.1	83.2	337	14	15.5	85.6
Average	......	295	21	12.7	75.7	2,356	22	13.1	77.3
Tennessee	1891	5	20	8.8	65.8	....	....	....	....
	1892	1	10	9.4	72.4	....	....	....	....
	1894	....	....	....	....	22	22	9.5	75.1
	1897	17	11	10.8	71.9	8	4	12.0	....
Average	......	23	13	10.3	70.6	30	17	10.2	75.1
Texas	1890	2	38	10.0	69.3	....	....	....	....
	1891	10	23	10.3	69.1	....	....	....	....
	1897	11	22	12.6	76.5	14	34	8.0	56.3
Average	......	23	24	11.4	72.7	14	34	8.0	56.3
Utah	1890	....	....	....	....	21	....	15.3	86.1
	1891	....	....	....	....		....	*a*11.0	80.0
	1892	....	....	....	....	43	27	*12.5	82.2
	1893	....	....	....	....		....	*a*11.6	79.5
	1894	....	....	....	....		....	*a*12.7	80.2
	1895	....	....	....	....		....	*a*13.5	81.5
	1896	....	....	....	....		....	*a*13.9	81.8
	1897	35	20	14.3	81.1	....	....	....	....
Average	......	35	20	14.3	81.1	64	27	13.4	83.5
Vermont	1897	8	22	14.2	84.1	32	17	16.3	84.2
Virginia	1890	20	15	10.8	74.0	....	....	....	....
	1891	72	21	11.1	76.0	....	....	....	....
	1892	13	12	12.0	79.6	....	....	....	....
	1893	14	16	13.3	83.9	....	....	....	....
	1897	34	21	11.6	76.2	5	*b*21	11.6	....
Average	......	153	19	11.4	76.8	5	21	11.6	....
Washington	1890	1	16	15.2	84.2	....	....	....	....
	1891	11	18	14.5	83.9	....	....	....	....
	1892	31	18	14.5	76.8	....	....	....	....
	1893	183	28	12.3	74.0	....	....	....	....
	1894	....	....	....	....	1,666	25	*13.5	82.6
	1895	....	....	....	....	521	17	16.2	87.9
	1896	....	....	....	....	211	6	13.4	80.9
	1897	34	27	13.7	80.7	60	23	13.6	75.7
Average	......	260	26	12.8	75.7	2,458	22	14.1	83.4
West Virginia	1892	12	14	11.3	68.5	....	....	....	....
	1897	14	19	15.4	80.4	....	....	....	....
Average	......	26	17	13.5	74.9	....	....	....	....

---

* The sign * indicates that the number given is 0.95× per cent of sugar reported since it was doubtful whether the per cent of sugar was expressed in terms of the weight of the juice or that of the beet, though probably the former.

a Report made on total crop by Utah Sugar Company, 1891-1896.

b Average weight (net) estimated from average gross weight.

Analyses of sugar beets grown in various States—Continued.

State.	Analyses by the United States Department of Agriculture.					Analyses by the State experiment stations.			
	Year	Number of samples.	Average weight.	Sugar in beet.	Purity coefficient.	Number of samples.	Average weight.	Sugar in beet.	Purity coefficient.
			Ounces.	*Per ct.*			*Ounces.*	*Per ct.*	
Wisconsin	1890	10	21	12.8	81.3	94	35	11.7	76.3
	1891	432	26	11.1	75.8	373	32	11.9	76.2
	1892	21	22	12.7	77.8	61	26	15.2	81.6
	1897	42	15	15.8	83.3	1,663	....	12.1	74.1
Average	......	505	25	11.4	76.6	2,191	32	12.1	74.7
Wyoming	1890	5	26	15.1	78.8	....	....	....	....
	1891	18	12	13.5	78.1	55	11	15.4	77.8
	1892	6	8	15.2	85.2	71	14	15.9	78.7
	1893	48	19	15.9	80.5	83	....	16.2	80.9
	1897	34	19	17.2	82.3	....	....	....	....
Average	......	111	18	15.8	80.8	159	13	15.8	78.8

NOTES ON PRECEDING TABLE.

In a few instances analyses reported to the stations by sugar companies or organizations designed for the promotion of the sugar industry have been included. It is noticeable that in many States but few analyses have been made. In view of this fact, it is well to be cautious in accepting the results of these few analyses as being representative of the beets grown in the State.

The reports from the State of California are especially incomplete. Most of the analyses reported are from data obtained in the laboratory of the Chino Valley Beet Sugar Company. In view of the fact that California has several very large and very successful factories, we do not regard the data included here of great value in judging of the State as a producer of high-grade sugar beets. We have data of factory averages obtained in California representing in some cases more than 100,000 tons of beets, showing that the State produces beets of very high sugar content. Factory averages have been reported this year higher than 15 per cent of sugar in the beets. It will be noticed that in most instances the results obtained by the Department of Agriculture corroborate those obtained in the stations.

A notable exception to this is in the tabulation of the results obtained with beets grown in the State of Washington. The Department of Agriculture, however, has only made about one-tenth as many analyses of Washington beets as the station. The average of the results of the large number of Washington beets analyzed shows that this State is destined to be a large producer of sugar.

In many cases the averages are based on very incomplete data, and therefore must not be considered strictly representative of all the results included. In figuring the general averages each annual average is weighted in proportion to the number of samples it represents.

INVESTIGATIONS IN SEED PRODUCTION.

The second line of experiments carried on by the Department of Agriculture during the season of 1897 was devoted especially to the culture of high-grade beets in cooperation with a few of the agricultural experiment stations. The localities selected for the experiments were such as would represent as wide a range as possible of climatic conditions, and be compatible with the time at the disposal of the Chemist of the Department for doing the work, and with the quantity of high-grade seeds on hand. It was not deemed advisable to go into the arid regions with these experiments, because it was not possible, in the short time at our disposal, to make proper preparations for the conduct of our work. Under authority of the Secretary of Agriculture the Chemist of the Department made arrangements with the following experiment stations to conduct the work under as nearly as possible identical conditions, except those pertaining to climate:

The agricultural experiment station of New York, at Geneva.
The agricultural experiment station of Indiana, at Lafayette.
The agricultural experiment station of Wisconsin, at Madison.
The agricultural experiment station of Iowa, at Ames.
The agricultural experiment station of Kentucky, at Lexington.
The agricultural experiment station of Tennessee, at Knoxville.

In order that the experiments might be conducted on plots of equal area, each director of the stations mentioned above was furnished with a diagram showing the manner in which it was thought most advisable to plant the different varieties of seeds. The diagram shown in figure 2 was accompanied by the following descriptive letter:

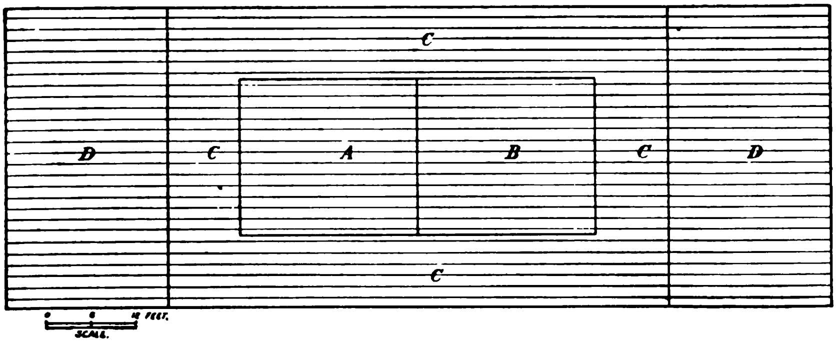

FIG. 2—Plot for guidance in planting sugar beets.

UNITED STATES DEPARTMENT OF AGRICULTURE,
DIVISION OF CHEMISTRY,
Washington, D. C., April 23, 1897.

DEAR SIR: For the sake of having complete uniformity in the comparative tests of high-grade beet seeds, I send herewith a diagram for the purpose of guiding you in the preparation of the plots and in the planting of the seed. The object of this diagram is to secure the planting of the high-grade seed in the interior smaller plots A B, each one of which has almost exactly the area of 500 square feet. If preferred the size of the interior plots may be varied so as to make each of them exactly one one-hundredth of an acre, namely, 435.6 square feet. I think it would be better, however, to keep the interior plots AB each 500 square feet, as they fit the rows as indicated by the horizontal line, allowing exactly 14 rows in the plots, of a total length, including both interior plots, of about 47.6 feet. The interior plots AB are surrounded by a border CCCC, which is to be planted with the high-grade commercial seeds which I shall send you. The end plots DD are to be planted with the same kind of high-grade commercial seeds as CCCC, but these end plots are not necessary to the success of the experiments. The object of the border CCCC is to surround the high-grade seeds AA with beets grown under the same conditions, so that the exterior rows of the plots AA may be subjected to the normal conditions of beet growth, which would not be the case if such small plots were left unprotected. The scale of these plots is 1 inch=12 feet. I think it is important that the soil of the plots be prepared in accordance with the directions contained in Bulletin No. 52, a copy of which I transmit herewith. The plowing and subsoiling should loosen the ground to a depth of not less than 16, and, better, to a depth of 18 inches, and the surface of the soil, after plowing and subsoiling, should be reduced to perfect tilth.

I am now awaiting the remainder of the high-grade seeds, which I expect in a few days. There will be two varieties of the high-grade seeds, one to be planted in Plot A and the other in Plot B. All the seeds sent you will be plainly marked, so that no mistake can be made. The quantity of seed required for plots A and B will be about 5 ounces. I think it best that the interior plots A and B at least should be planted by hand. The number of seeds in the 5 ounces being known, they should be planted in groups at intervals of 9 inches; that is, in such a way as to secure one good, vigorous plant at about every 9 inches in the row after thinning. Five ounces of seed will contain approximately 5,000 seeds, and in the two plots A and B there will be 888 hills, which gives approximately nearly 6 seeds to a hill. In this case the planting would be accomplished as follows: Six seeds placed in the row at distances of 1 inch apart followed by an interval of 3 inches, then again 6 seeds at intervals of 1 inch, and so on. This grouping is shown in the following line:

9 in. 9 in.

. . .   .

Of course the spacing will vary according to the number of seeds to be planted.

If there be anything in connection with the diagram that you do not understand please let me know.

Respectfully,
H. W. WILEY, *Chief of Division.*

The high-grade seeds furnished for planting the above plots were as follows:

(1) The Vilmorin Improved, grown at the experiment station of the United States Department of Agriculture at Schuyler, Nebr., in 1893. This station was abolished in the autumn of that year by Secretary Morton, and the principal part of all the high-grade seeds on hand was sold to the Oxnard Beet Sugar Company, of Grand Island, Nebr. A small portion of each variety was retained, however, in the hope that at some day the experiments might be reestablished. When subjected to a germination test, however, of all the varieties which had been preserved, only the Vilmorin Improved showed unimpaired vitality. All the other varieties grown at Schuyler showed a vitality too low to warrant planting.

(2) Original Kleinwanzlebener, grown by Kühn & Co., Naarden, near Amsterdam, Holland. These seeds were from specially analyzed mothers, showing the very highest qualities for seed production.

(3) High-grade commercial seed, grown by F. Demesmay, Cysoing, France. These seeds were not grown from specially analyzed mothers, but represented the high-grade commercial seeds produced at that place.

These three varieties were furnished for planting in Section B. There were also sent at the same time some of the high-grade commercial Kleinwanzlebener and Vilmorin's La Plus Riche for planting sections CCCC and DD, as indicated in the diagram. These seeds were sent to the various stations specified above on the 24th of April, 1897. The high-grade seeds which were to be used in planting Section A had not yet been received, and were not forwarded at that time.

The seeds ordered from Europe did not arrive until May 15, and were sent at once to the several stations on that day. In addition, seeds were received from August Rölker & Sons, representing Dippe Brothers, at New York, and from Martin Grashoff, of Quedlinburg. These seeds were also sent for planting the margins of the plot indicated above.

In the general instructions given to the directors of the stations it will be noticed that all the details of the work were left to be decided by them at the proper time, as any directions for time of planting, etc., would be but futile. Each one of the directors undertook to do the work strictly in accordance with the instructions provided in so far as the preparation of the land, planting, cultivation, and harvesting of the samples were concerned. The Chemist of the Department visited three of the stations during the season and conferred personally with the directors in regard to the progress of their work. The other directors were communicated with only by letter.

In the analytical work samples were selected according to instructions and sent to the Department of Agriculture, and others were analyzed in the laboratories of the collaborating experiment stations.

On May 6, the high-grade seeds not yet having arrived from Europe, I sent to each of the stations for planting Section A some high-grade seeds grown by Martin Grashoff, of Quedlinburg, obtained from Mr. Jellinek, an agent of the grower in this country. I suggested that Section A be planted with this seed, and then if the other seed expected from Germany came in time the plants could be dug out and the section replanted. The name of the seeds sent for planting Section A was White Improved Imperial Elite, which were produced by a cross of another variety with the Kleinwanzlebener. Directions for planting the seeds according to the plot were furnished each director.

The additional quantity of high-grade sugar-beet seed ordered from Dippe Brothers, Quedlinburg, Germany, was received and distributed to the stations on the 17th of May. In most cases the beets in Section A which were previously planted were not dug out, but the new seeds were planted in other localities.

The conditions of growth varied greatly in the different localities during the season. At the New York station the spring was backward and cold, and the planting and first development of the beets were delayed. The subsequent conditions were favorable to good growth. The beets received no backset, and reached a fair maturity by the 1st of October. The autumn was mild and cool, and dry enough to prevent second growth, so that the beets could be left in the ground with perfect security until late in November.

At the Indiana station less favorable conditions obtained. A poor stand of the beets was secured in many instances where a perfect stand was secured at the New York station. The early leaves were badly eaten by an insect, and this prevented the early rapid development of the plant. Subsequently a period of extreme drought set in, lasting for nearly two months—during July and August. The result of all these unfavorable conditions was practically a complete failure of the crop, so that even in the case of the beets which were secured there were evidences of arrested development. The general result of the experiment was exceedingly discouraging.

At the Wisconsin station the field which was selected for the growth of the beets was not particularly well suited to the purpose. It had not been under previous cultivation for many years, and a portion of it, as is seen in the report of the director, suffered severely from various causes. The special plots which were cultivated in the high-grade seeds gave fairly good results, as will be seen farther on, and the beets produced were of good size, fair shape, and fine quality.

At the Iowa station fairly good seasonal conditions prevailed, and the character of the beets produced on the specially prepared plots was satisfactory.

At the Kentucky station the beets obtained a good start, and grew well for the greater part of the season. They were slightly retarded by dry weather at one period of their growth, but on the whole reached a fair stage of maturity without untoward accidents. The beets which were harvested in September and October showed a higher content of sugar than those that were left later in the ground, and this is probably due to the second growth, which was produced by the warm climate of that locality. The sugar content was exceedingly low, and the data secured from the station show conclusively that Kentucky is not in the list of possibilities as a sugar-producing State in so far as beets are concerned.

The data from Tennessee are extremely meager, and no definite conclusions can be drawn from those at hand.

In the study of the data received, it will be convenient to begin with the most southern station, namely, Tennessee, and then continue with the Kentucky, Indiana, Iowa, Wisconsin, and New York station in the order named.

TENNESSEE.

The results obtained at the Tennessee station were extremely unsatisfactory. On account of the poor quality of the beets, only one sample was sent for analysis, which was harvested on the 25th of September. These beets were so small as to hardly deserve the name, and no attempt was made to determine the purity of the juice. It is evident, from an inspection of the table which follows, that there was nothing in the result of the experiment to justify a further examination of the beets produced.

The cause of failure in Tennessee has been reported by the secretary of the station in the letter given below, and therefore no further explanation need be made here of the failure to attain even fairly satisfactory results.

THE AGRICULTURAL EXPERIMENT STATION
OF THE UNIVERSITY OF TENNESSEE,
Knoxville, February 15, 1897.

DEAR SIR: A reference to plat sent you May 26, 1897, will explain the following: Sugar beets grown from seed sown May 19, 20, 1897, were lifted when properly ripe, tops removed and put into separate piles on the ground close by, and covered with earth. In this condition the various lots remained until taken up to be weighed on 13th of this month. Roots found in good order, and are now being fed to our cows. The weights of the several lots were as follows:

Plat.	Variety and from whence received.	Area.	Weight.
		Sq. ft.	*Pounds.*
Subdivision N	Vilmorin's Improved White, from P. Henderson & Co., New York.	880	175
Subdivision J	Kleinwanzlebener Elite, Dippe Brothers, from Department.	589	54
Subdivision D	Vilmorin's, la plus rich, from Department	1,568	280
Subdivision C	High grade Kleinwanzlebener, from Department	1,642	369
Subdivision A	Memte Ober Wurst, Quedlinburg, Dippe Brothers, from Department.	448	64.5
Subdivision B (2 rows).	Original Kleinwanzelebener (Holland), from Department.	64	16.5
Subdivision B (3 rows).	Vilmorin's Improved (Schuyler, Nebr.), from Department.	96	12
Subdivision B (9 rows).	Demesmay, from Department	288	56
Subdivision E (triangle).	White Improved Imperial Elite (Grashoff), from Department.	224	124.5
		5,796	1,115.5

8,715 pounds per acre.

A miserably poor yield.—Soil prepared in best manner; germination good; when first leaves were formed an excellent stand. A few days after an incursion of flea beetles destroyed almost every plant in an irregular strip across the whole plat; this was done between the hours of 11 a. m. and 3 p. m., in one day. Cultivation was well and thoroughly done, but the planting was much too late. A plat of Vilmorin's Improved White grown near the farm building, the seed for which was planted April 1, gave us a very heavy yield. These were planted for table use and for stock feeding, and were purposely grown to make feed stuff, not for sugar.

Very respectfully, yours,

CHAS. F. VANDERFORD,
Secretary.

DR. H. W. WILEY,
Chief Division of Chemistry, U. S. Department of Agriculture,
Washington, D. C.

The details of the analytical data are found in the accompanying table of data.

KENTUCKY.

Special care was taken by the director of the station at Lexington to secure satisfactory results. During the early part of the season the beets grew exceptionally well and presented a fine appearance. The quantity produced was fairly good, although the beets were somewhat irregular in size, some of them being quite large and others quite small. The sugar content of the beets and the purity of the juice were both extremely low. The first series of samples was analyzed on the 28th of September, and a second set of samples from two of the varieties was analyzed at a later date. The original Kleinwanzlebener (Holland) seed was represented by thirty-seven beets in this second sample, the average size of which was small and the sugar content medium. The White Improved Imperial Elite was represented in the second sample by forty-eight beets, also extremely small, and with a low content of sugar. The final harvest of the beets resulted in securing three barrels of beets of fine size and shape, but when these beets were perforated for analysis it was found that the content of sugar was low, falling, in some cases, as low as 2 per cent. The sugar content in general was so small that it was not deemed worth while to report it, as the beets were utterly worthless for seed production. The depressing influence of climate on the character of the beets is illustrated in a most striking manner by a comparison of the results obtained from beets grown in Kentucky and in Geneva, N. Y., from the same seeds, and under as nearly as possible identical conditions of culture.

INDIANA.

The unfortunate seasonal conditions which obtained at the experiment station at Lafayette have already been mentioned. The result of the prolonged drought during the growing season was a diminution of the weight of the beets to such an extent that for practical purposes they were useless. For this reason the data obtained are of little value. On account of the inferior character of the beets, no attempt was made to select any of them for mothers for the subsequent production of seed. The analytical data connected with the special plot work in Indiana are found in the tables following.

IOWA.

Only one set of samples was received from the plots grown in Iowa, the sample of the Demesmay having been harvested on the 25th of September and all the other samples on the 13th of November. The average size of the beets received was small, the percentage of sugar only fair, and the purity not up to the minimum standard. The seasonal influences at Ames were therefore evidently inferior in sugar-producing qualities to those which obtained in New York. The final harvest of beets was not forwarded to the Department for the purpose of selecting mothers by reason of a misunderstanding whereby the different varieties were mixed in such a way that the separation of them was impracticable. A general statement in regard to the special plot work done at Ames is contained in the following letter from Director Curtiss:

AMES, IOWA, *January 25, 1898.*

DEAR SIR: Replying to your inquiry concerning the test of high-grade sugar-beet seed furnished by your Department, will say that we have forwarded you two samples of the Vilmorin's Elite from the plats grown according to your instructions, and have lately had your report of the last sample. The beets from these plats were analyzed by Dr. Weems, of our chemistry section, with the following results:

Variety.	Sugar.	Purity coefficient
	Per cent.	
Vilmorin's Élite	16.07	84.30
Demesmay	14.30	78.38
Improved Imperial Élite	13.31	76.14
Kleinwanzlebener	16.91	90.76

These samples and the one forwarded to you gave substantially the same results and were harvested November 11. The first sample sent you was taken earlier and was probably immature. The past season was quite backward here, and the beet crop correspondingly late in maturing. Owing to a change in our field-experiment department during the past year, the beets from these plats were, through a misunderstanding, thrown together instead of being kept separate after the analyses were made, and we will not be able to distinguish between varieties in testing these beets and carrying on future work along this line. We very much regret that this mistake has occurred, as we would like to continue the work of developing high-grade beets for seed production. We will be glad to cooperate with you again during the coming season if you can furnish us more seed.

Very truly, yours,

C. F. CURTISS.

Dr. H. W. WILEY,
Washington, D. C.

The analytical data derived from the analyses of beets sent from the Iowa station to this laboratory are of little value. Only one set of samples was received, namely, of the Demesmay variety, harvested on the 25th of September, and of the three varieties harvested on the 13th of November. With the exception of the Vilmorin Élite, which was received on the 22d of November, the analytical data are not satisfactory. In the case of the variety just mentioned the sugar content and the purity were satisfactory, but the beets were very much under size. It is evident that the data obtained in the past season do not fairly represent the capabilities of Iowa, either for the production of good commercial beets or for the growth of beets for seed-producing purposes. The analytical data obtained on analysis of the samples received at the Department are found in the table given farther on.

WISCONSIN.

Complete details of experiments with high-grade beet seeds, grown under the auspices of the Department of Agriculture, are found in the

Wisconsin report, contained in Bulletin No. 64 of that station. These details are so valuable as to warrant their reproduction in full:

EXPERIMENTS WITH HIGH-GRADE SUGAR-BEET SEED.

These experiments were, as already stated, conducted under the auspices of the United States Department of Agriculture. In a letter received in the early part of April last, the chief chemist of the Department, Dr. H. W. Wiley, requested this station to cooperate with the Department in growing a number of varieties of beets from high-grade seed furnished by them, giving the beets the best of conditions in respect to subsoiling, preparation of the seed bed, and cultivation. Some of the kinds of seed sent were produced by the highest possible scientific culture from specially analyzed beets, which were stated to average 19 per cent of sugar. According to the directions received, the Government plat was surrounded on all sides by our regular beet field and was located in the southeastern quarter of our main field. The different kinds of seed received and planted by hand on May 22 were as follows:

Plat A.—Dippe Brothers, Vilmorin Élite R I, from Dippe Brothers, Quedlinburg, Germany.

Plat B.—1. Original Kleinwanzlebener, grown by Kühn, Naarden, Holland. 2. Vilmorin Improved, grown at United States Sugar Beet Station at Schuyler, Nebr. 3. Demesmay sugar-beet seed, grown by F. Demesmay, Cysoing (Nord), France.

Plat C.—High-grade Commercial Kleinwanzlebener.

Plat D.—High-grade Commercial Vilmorin's Improved "La Plus Riche."

White Improved Imperial Élite, grown by Martin Grashoff, Quedlinburg, Germany.

Dippe Brothers, Kleinwanzlebener Élite W I, from Dippe Bros., Quedlinburg, Germany.

The plats were arranged, as suggested by Dr. Wiley, in the following manner: Plats A and B, each 21 by 24 feet, were placed in the middle and were surrounded by a border, CC, 67 feet long and 9½ feet wide; the plats D^1 and D^2 were placed at the east and west ends of the C plat, being 21 by 40 feet. South and north of the whole plat three rows were run 110 feet long, in which were planted the varieties given in the preceding statement, White Imperial being planted in the south three rows, and Kleinwanzlebener Élite in the north three rows. The rows were 18 inches apart. The effort was to have one good vigorous beet plant at about every 9 inches in the row after thinning.

The germinations of the seed planted in this experiment, as well as of that planted in our other trials, were determined by Professor Goff, and are given on pages 300-301 of our Fourteenth Annual Report. It will be seen that the germinative power of the different kinds of seed was very good, with the possible exception of the Schuyler, Nebr., seed, which was old, and the Dippe Brothers' Vilmorin Élite seed. The average germination of the seed was 167 per cent, ranging from 115 to 231 per cent, the latter result being obtained with the White Improved Imperial Élite.

The first samples of the beets raised on the Government plat were taken September 20; another sample was taken September 27, and after that time every fourteen days until the beets were harvested, on November 5. In sampling the beets four beets were dug of each kind. Two of these were forwarded to Washington, D. C., to the Department of Agriculture, and the other two retained for analysis in our own laboratory.

The results of the analyses made by the writer are given in the following table. The C^1 samples were taken south of the A and B plats and the C^2 samples north of these plats. In the same manner the D^1 and D^2 samples were taken from the plats east and west, respectively, of the central plats.

Main field, Government plat.

Variety.	Date of sampling.	Per cent root of whole plant.	Weight of beets.	Analysis of juice.		
				Specific gravity.	Sugar.	Purity coefficient
			Pounds.		*Per cent.*	
Imperial Elite	Sept. 20	70	0.21	1.0755	14.44	79.1
	Sept. 27	70	.40	1.0934	17.92	80.5
	Oct. 11	78	.40	1.0834	17.04	85.0
	Oct. 25	80	.58	1.0858	16.35	79.4
	Nov. 5	....	.83	1.0740	14.35	80.1
Average	....	....	.48	....	16.02	80.8
Vilmorin La Plus Riche, D_1	Sept. 20	73	.34	1.0882	16.96	80.4
	Sept. 27	73	.80	1.0923	17.58	79.9
	Oct. 11	72	.98	1.0895	17.93	83 8
	Oct. 25	82	.95	1.0860	16.40	79.5
	Nov. 5	....	1.20	1.0882	16.53	78.3
Average	....	....	.85	....	17.08	80.4
High-grade Kleinwanzlebener, C_1	Sept. 20	73	.37	1.0825	16.45	83.0
	Sept. 27	70	.55	1.0898	17.21	80.0
	Oct. 11	59	.50	1.0870	16.15	77.5
	Oct. 25	78	.50	1.0810	14.35	73.6
	Nov. 5	....	1.13	1.0845	16.90	83.5
Average	....	....	.61	....	16.21	79.5
Vilmorin Improved, Nebr., B	Sept. 20	70	.75	1.0725	15.06	85.7
	Sept. 27	76	.45	1.0810	16.70	85.7
	Oct. 11	80	1.13	1.0848	17.01	83.6
	Oct. 25	91	.75	1.0857	15.86	77.2
	Nov. 5	....	.71	1.0800	15.71	81.5
Average	....	....	.76	....	16.07	82.7
Original Kleinwanzlebener, Holland, B	Sept. 20	68	.45	1.0860	16.63	80.7
	Sept. 27	67	.20	1.0946	18.57	82.4
	Oct. 11	73	.40	1.0935	17.95	80.6
	Oct. 25	73	.30	1.0980	17.34	74.5
	Nov. 5	....	.35	1.0920	18.65	81.8
Average	....	....	.37	....	17.83	80.0
Dippe's Kleinwanzlebener	Sept. 20	64	.70	1.0695	14.57	86.3
	Sept 27	68	.90	1.0836	17.11	85.2
	Oct. 11	71	.93	1.0917	18.17	83.0
	Oct. 25	71	.50	1.1070	21.45	85.2
	Nov. 5	....	.95	1.0812	16.42	84.0
Average	....	....	.80	....	17.54	84.7
Vilmorin's La Plus Riche, D_2	Sept. 20	67	1.03	1.0735	16.13	90.6
	Sept. 27	72	1.15	1.0800	16.90	83.0
	Oct. 11	73	1.23	1.0868	17.56	84.4
	Oct. 25	78	1.35	1.0917	18.88	86.3
	Nov. 5	....	....	....	....	....
Average	....	....	1.19	....	17.37	86.1
High-grade Kleinwanzlebener, C_2	Sept. 20	72	1.05	1.0850	17.94	87.9
	Sept. 27	65	.70	1.0842	16.70	82.6
	Oct. 11	75	.70	1.0885	17.57	83.0
	Oct. 25	82	1.30	1.0940	19.18	85.7
	Nov. 5	....	....	....	....	....
Average	....	....	.94	....	17.85	84.8
Demesmay Improved, B	Sept. 20	76	.80	1.0655	13.23	82.8
	Sept. 27	81	.93	1.0695	13.49	79.8
	Oct. 11	78	1.10	1.0678	12.85	77.9
	Oct. 25	89	.85	1.0798	15.95	83.0
	Nov. 5	....	.93	1.0690	13.66	81.4
Average	....	....	.92	....	13.84	81.0
Dippe Vilmorin, A	Sept. 20	63	.62	1.0790	16.05	84.3
	Sept. 27	73	1.00	1.0852	16.86	82.5
	Oct. 11	73	1.10	1.0895	17.49	81.7
	Oct. 25	82	1.03	1.0920	18.34	83.6
	Nov. 5	....	.75	1.0827	16.91	85.1
Average	....	....	.90	....	17.18	83.4

We notice that the per cent of sugar in the juice but rarely came over 18 in case of the different varieties, the average figures ranging from 13.84 per cent (Demesmay) to 17.85 per cent (High-grade Commercial Kleinwanzlebener, C_2); the purity of the beet juice was good, viz, lowest 79.5 (High-grade Commercial Kleinwanzlebener, C_1), highest 86.1 (Vilmorin La Plus Riche, D_2).

The average results of the analyses of these beets obtained by the Department of Agriculture and in this laboratory are given below:

Determinations made by—	Number of analyses.	Polariscope method.	Alc. extraction method.	Purity coefficient.
United States Department of Agriculture	38 (31*)	16.27	....	84.7
Wisconsin Experiment Station	38 (31*)	16.09	15.13	82.0

* Number of determinations of purity of juice.

While the agreement is as good as could be expected between the results obtained by the polariscope method, the purity coefficient differs rather more than allowable in duplicate samples. The two sets of analyses differ in this way, that the Department of Agriculture samples were always analyzed at least several days after our analyses were made, since the latter were always finished within twenty-four hours from the time of sampling. In single instances, variations occurred between the Department of Agriculture and our analyses of 3 per cent of sugar in the juice and of over 7 per cent purity, owing to differences in the stage of maturity of the beets analyzed; it is evident that no absolutely correct idea of the sugar content of the beets in a certain plat or field can be obtained by pulling and analyzing two single beet roots, even if these do appear to be at about average stage of maturity.

The yield of beets from the plat, obtained at harvesting, November 5, and the calculated yield of beets and of sugar per acre, are shown in the following table:

Yield of beets and of sugar, Government plat.

Name of variety.	Yield of beets.		Average weight of beets.	Sugar in the beet.	Sugar per acre.
	From plat.	Per acre.			
	Pounds.	*Pounds.*	*Pounds.*	*Per cent.*	*Pounds.*
Imperial Elite	272.3	24,210	0.45	13.63	3,300
Vilmorin La Plus Riche	1,167.3	28,290	.64	15.70	4,441
High-grade Commercial Kleinwanzlebener	1,170.0	30,660	.56	16.05	4,920
Dippe Brothers Kleinwanzlebener Elite	311.7	34,380	.66	15.60	4,995
Dippe Brothers Vilmorin Elite	336.6	29,090	.58	16.06	4,672
Demesmay	234.4	31,520	.61	12.98	4,092
Vilmorin, Schuyler, Nebr	76.7	30,940	.59	14.92	4,616
Original Kleinwanzlebener, Holland	26.0	15,730	.27	17.72	2,788
Averages, etc	3,595.0	28,103	....	15.04	4,228

The average yield of beets per acre obtained was over 14 tons, or about 5 tons more than the yield obtained from either half of the main field. The average calculated yield of sugar per acre was 4,228 pounds, the lowest yield being obtained in case of Original Kleinwanzlebener, Holland (2,788 pounds), which variety plainly suffered most from the drought, and the highest in case of Dippe's Kleinwanzlebener Elite (4,995 pounds).

ANALYSES MADE AT THE LABORATORY OF THE DEPARTMENT OF AGRICULTURE.

Samples of beets from the high-grade plots were sent from time to time to the laboratory of the Department of Agriculture for analysis, and finally all the remaining beets of proper size were forwarded for examination. The following table contains the analyses of the samples received from the various stations of the three separate harvests of beets, ranging from the last of September to the last of October, together with the analyses of all the samples of the high-grade beets harvested in the middle of November:

Table showing analyses of beets of high grade from experiment stations of Tennessee, Kentucky, Indiana, Iowa, Wisconsin, and New York.

KNOX COUNTY, TENN.

[Experiment Station, Knoxville.]

Serial No.	Variety.	Time of planting.	Time of harvesting.	Date received.	Number of beets.	Average weight.	Sugar in the beets.	Purity coefficient.
		1897.	1897.	1897.		*Ounces.*	*Per ct.*	
200	White Improved Imperial Elite	May 24	Sept. 25	Sept. 27	2	4	11.5	....
201	Kleinwanzlebener Elite	do	do	do	2	7	10.7	....
203	Original Kleinwanzlebener (Dippe Brothers)	May 18	do	do	2	3	12.5	....
204	Original Kleinwanzlebener (Holland)	do	do	do	4	1	12.5	....
206	High grade Kleinwanzlebener	do	do	do	2	6	12.0	....
202	Vilmorin's "La Plus Riche"	do	do	do	2	7	10.6	....
205	Vilmorin's Improved	do	do	do	5	1	13.2	....
207	Demesmay	do	do	do	3	1	13.5	....

FAYETTE COUNTY, KY.

[Experiment Station, Lexington.]

Serial No.	Variety.	Time of planting.	Time of harvesting.	Date received.	Number of beets.	Average weight.	Sugar in the beets.	Purity coefficient.
		1897.	1897.	1897.				
285	Original Kleinwanzlebener (Holland)	....	Sept. 27	Sept. 29	....	21	13.3	72.5
834–870	do	....	Oct. 14	Oct. 18	37	7	15.8	....
286	Vilmorin's Improved (Schuyler, Nebr.)	....	Sept. 27	Sept. 29	....	19	10.9	68.5
287	Demesmay	....	do	do	....	18	9.5	65.0
293	White Improved Imperial Elite	....	do	do	....	17	10.9	68.1
785–832	do	....	Oct. 14	....	48	7	11.1	....

TIPPECANOE COUNTY, IND.

[Experiment Station, Lafayette.]

Serial No.	Variety.	Time of planting.	Time of harvesting.	Date received.	Number of beets.	Average weight.	Sugar in the beets.	Purity coefficient.
		1897.	1897.	1897.				
109	Original Kleinwanzlebener (Holland)	May 5	Sept. 24	Sept. 27	2	4	16.5	....
436	do	do	Oct. 8	Oct. 10	2	5	14.3	....
2203	do	do	Nov. 22	Nov. 24	5	6	19.1	84.4
171	Kleinwanzlebener Elite (Dippe Brothers)	May 19	Sept. 24	Sept. 26	2	3	14.4	....
448	do	do	Oct. 8	Oct. 10	2	4	14.7	....
2202	do	do	Nov. 22	Nov. 24	6	9	18.5	83 6
172	Demesmay	May 5	Sept. 24	Sept. 26	2	5	12.6	....
449	do	do	Oct. 8	Oct. 10	2	8	12.5	....
2204	do	do	Nov. 22	Nov. 24	14	9	14.3	80.6
178	Vilmorin's Improved Elite (Dippe Brothers)	May 19	Sept. 24	Sept. 26	2	4	13.9	....
447	do	do	Oct. 8	Oct. 10	2	4	14.6	....
2206	do	do	Nov. 22	Nov. 24	5	7	16.5	80.1
180	Vilmorin's Improved (Schuyler, Nebr.)	May 5	Sept. 24	Sept. 26	2	6	14.5	....
2205	do	do	Nov. 22	Nov. 24	10	7	15.4	81.3
430	Vilmorin's Improved	do	Oct. 8	Oct. 10	2	6	16.1	....

Table showing analyses of beets of high grade from experiment stations of Tennessee, Kentucky, Indiana, Iowa, Wisconsin, and New York—Continued.

STORY COUNTY, IOWA.

[Experiment Station, Ames.]

Serial No.	Variety.	Time of planting.	Time of harvesting.	Date received.	Number of beets.	Average weight.	Sugar in the beets.	Purity coefficient.
		1897.	1897.	1897.		*Ounces.*	*Per ct.*	
249	Demesmay	May 29	Sept. 25	Sept. 28	3	11	13.9	....
2078	White Improved Imperial Elite	....do	Nov. 13	Nov. 22	2	13	16.7	79.1
2088	Vilmorin's Improved	....do	....do	....do	2	19	13.0	72.5
2099	Vilmorin's Elite	....do	....do	....do	2	12	17.3	82.6
2100	Original Kleinwanzlebener	....do	....do	....do	2	20	12.8	72.4

DANE COUNTY, WIS.

[Experiment Station, Madison.]

		1897.	1897.	1897.				
217	Dippe's Kleinwanzlebener	May 22	....	Sept. 29	2	10	15.0	80.5
882	.....do	....do	....	Oct. 12	2	11	18.5	87.3
1465	.....do	....do	....	Oct. 27	2	9	19.5	....
1912	.....do	....do	Nov. 3	Nov. 17	12	16	15.3	83.1
	Averages*	....	....	....	....	14	15.9	83.3
222	Original Kleinwanzlebener (Holland)	May 22	....	Sept. 29	2	5	15.4	....
881	.....do	....do	....	Oct. 12	2	8	18.9	87.2
1469	.....do	....do	....	Oct. 27	2	7	18.9	....
1913	.....do	....do	Nov. 2	Nov. 17	11	6	18.7	80.7
	Averages*	....	....	....	....	6	18.4	82.0
225	Kleinwanzlebener	May 22	....	Sept. 29	2	13	14.6	85.0
877	.....do	....do	....	Oct. 12	2	9	16.3	82.2
1468	.....do	....do	....	Oct. 27	2	13	17.3	84.1
226	.....do	....do	....	Sept. 29	2	9	13.8	86.3
878	.....do	....do	....	Oct. 12	2	6	15.5	86.2
1464	.....do	....do	....	Oct. 27	2	6	18.5	....
1918	.....do	....do	Nov. 3	Nov. 17	188	15	17.3	85.1
	Averages*	....	....	....	....	14.7	17.2	85.1
218	White Improved Imperial Elite	May 22	....	Sept. 29	2	9	14.0	86.0
876	.....do	....do	....	Oct. 12	2	8	17.1	....
1463	.....do	....do	....	Oct. 27	2	5	18.3	....
1911	.....do	....do	Nov. 3	Nov. 17	12	15	15.4	83.2
	Averages*	....	....	....	....	12.4	15.5	83.5
219	Dippe's Vilmorin Elite	May 22	....	Sept. 29	2	14	14.3	84.3
880	.....do	....do	....	Oct. 12	2	10	18.3	87.2
1466	.....do	....do	....	Oct. 27	2	16	18.5	86.9
1917	.....do	....do	Nov. 2	Nov. 17	115	14	17.7	86.7
	Averages*	....	....	....	....	14.0	17.7	86.7
221	Vilmorin's Improved Schuyler, seed	May 22	....	Sept. 29	2	16	13.6	82.6
879	.....do	....do	....	Oct. 12	2	15	16.8	85.0
1461	.....do	....do	....	Oct. 27	2	12	16.2	82.1
1916	.....do	....do	Nov. 2	Nov. 17	24	12	15.6	82.5
	Averages*	....	....	....	....	12.4	15.6	82.7

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* In figuring the averages, each analysis is valued in proportion to the weight of the sample.

Table showing analyses of beets of high grade from experiment stations of Tennessee, Kentucky, Indiana, Iowa, Wisconsin, and New York—Continued.

DANE COUNTY, WIS.—Continued.

Serial No.	Variety.	Time of planting.	Time of harvesting.	Date received.	Number of beets.	Average weight.	Sugar in the beets.	Purity coefficient.
		1897.	1897.	1897.		*Ounces.*	*Per ct.*	
223	Vilmorin's "La Plus Riche"	May 22	....	Sept. 29	2	18	14.9	83.4
871	.....do	....do ...	....	Oct. 12	2	16	17.9	88.2
1462	.....do	....do ...	....	Oct. 27	2	12	17.6	85.2
224	.....do	....do ...	....	Sept. 29	2	13	14.3	86.2
875	.....do	....do ...	....	Oct. 12	2	8	19.2	....
1467	.....do	....do ...	....	Oct. 27	2	10	19.0	85.4
1915	.....do	....do ...	Nov. 3	Nov. 17	236	15	17.7	86.7
	Averages†	....	....	....	....	15	17.7	86.8
220	Demesmay	May 22	....	Sept. 29	2	12	13.4	84.8
1470	.....do	....do ...	....	Oct. 12	2	12	15.0	83.5
1914	.....do	....do ...	Nov. 2	Nov. 17	91	13	13.6	81.0
	Averages†	....	....	....	....	13	13.6	81.1

ONTARIO COUNTY, N. Y.

[Experiment station, Geneva.]

Serial No.	Variety.	Time of planting.	Time of harvesting.	Date received.	Number of beets.	Average weight.	Sugar in the beets.	Purity coefficient.
		1897.	1897.	1897.				
227	White Improved Imperial Elite	May 19	Sept. 27	Sept. 28	4	14	12.6	80.6
1409	.....do	....do ...	Oct. 14	Oct. 15	4	16	14.8	82.0
	.....do	....do ...	Oct. 29 Oct. 30	....	174	18	15.3	(*)
	Averages†	....	....	....	....	18	15.2	81.3
228	Vilmorin's "La Plus Riche"	May 19	Sept. 27	Sept. 28	4	20	15.1	85.5
231	.....do	....do ...	....do ...	....do ...	4	17	15.6	87.2
1403	.....do	....do ...	Oct. 14	Oct. 15	4	16	16.8	84.2
1410	.....do	....do ...	....do ...	....do ...	4	16	16.6	85.7
	.... do	....do ...	Oct. 29 Oct. 30	....	207	20	18.3	(*)
	Averages†	....	....	....	....	20	18.1	85.6
229	Vilmorin's Improved (Schuyler, Nebr.)	May 15	Sept. 27	Sept. 28	5	20	14.2	84.2
1406	.....do	....do ...	Oct. 14	Oct. 15	4	16	15.2	87.8
	.....do	....do ...	Oct. 29 Oct. 30	....	32	18	15.7	(*)
	Averages†	....	....	....	....	18	15.5	85.6
234	Vilmorin's Improved	May 19	Sept. 27	Sept. 28	4	15	13.6	82.2
1404	.....do	....do ...	Oct. 14	Oct. 15	4	15	14.6	81.4
	Averages†	....	....	....	....	15	14.1	81.8
230	Demesmay	May 19	Sept. 27	Sept. 28	4	18	13.3	82.8
1401	.....do	....do ...	Oct. 14	Oct. 15	4	16	12.3	79.2
	.....do	....do ...	Oct. 29 Oct. 30	....	107	18	15.9	(*)
	Averages†	....	....	....	....	18	15.7	81.1
232	Vilmorin's Improved Elite (Dippe Brothers)	May 19	Sept. 27	Sept. 28	4	19	15.2	86.0
1407	.....do	....do ...	Oct. 14	Oct. 15	4	16	16.7	84.9
	.....do	....do ...	Oct. 29 Oct. 30	....	64	19	18.1	(*)
	Averages†	....	....	....	....	19	17.9	85.5

* Not included in averaging the purity coefficients.

† In figuring the averages, each analysis is valued in proportion to the weight of the sample it represents.

Table showing analyses of beets of high grade from experiment stations of Tennessee, Kentucky, Indiana, Iowa, Wisconsin, and New York—Continued.

ONTARIO COUNTY, N. Y.—Continued.

Serial No.	Variety.	Time of planting.	Time of harvesting.	Date received.	Number of beets.	Average weight.	Sugar in the beets.	Purity coefficient.
		1897.	1897.	1897.		*Ounces.*	*Per ct.*	
233	High-grade Commercial Kleinwanzlebener	May 19	Sept. 27	Sept. 28	4	20	15.1	86.4
1402	do	do	Oct. 14	Oct. 15	4	15	15.2	83.2
	do	do	Oct. 29 Oct. 30		224	18	17.8	(*)
	Averages†					18	17.7	85.0
235	Original Kleinwanzlebener (Holland)	May 19	Sept. 27	Sept. 28	4	18	16.2	86.7
1405	do	do	Oct. 14	Oct. 15	4	13	16.4	84.7
	do	do			7	18	19.2	(*)
	Averages†					17	17.7	85.8
1408	Kleinwanzlebener Elite (Dippe Brothers)	May 19	Oct. 14	Oct. 15	4	16	17.3	84.6
	do	do	Oct. 29 Oct. 30		211	20	18.7	
	Averages					20	18.7	

* Not included in averaging the purity coefficients.

† In figuring the averages, each analysis is valued in proportion to the weight of the sample it represents.

Discussion of above data.—No further discussion of the analytical data contained in the above table is necessary, except in the case of the samples received from Wisconsin and New York. These samples were exceptionally fine. By an unfortunate misunderstanding all the beets received from Wisconsin were reduced to pulp for the purpose of getting an average sample for analysis. The selection for mother beets was, therefore, confined to the samples from New York.

WISCONSIN.

Almost uniformly good results were obtained in these experiments. The Original Kleinwanzlebener (Holland) seed produced beets, however, too small for all practical purposes, although the sugar content and purity were high. The largest beets and those of the highest purity were produced by the Vilmorin La Plus Riche seed. The Demesmay seed which were used were only the commercial article, and were not grown from specially analyzed mothers. It is not surprising, therefore, to see that they produced a crop which was the poorest of all in sugar content.

The particular analyses of the most importance are those which were made on the beets received November 17, and harvested on the 3d of November. These practically represent the beets at their full maturity, as it is not probable that they would improve in quality in the climate of Madison after the 1st of November. The analyses also represent the greatest number of beets, and therefore are the most reliable. The largest number of beets of proper size and shape were produced by the Vilmorin La Plus Riche seed, and the smallest by the Original Kleinwanzlebener. The beets grown from the Schuyler seed are of particular interest because they represent the link of union between the experiments which were discontinued by the Department in 1893 and reinaugurated in 1897. The average size of the beets produced by the Schuyler seed is somewhat small, but the content of sugar and the purity are satisfactory. Upon the whole, the effect of high-grade seed and high culture are most distinctly marked. It is only necessary to compare the results obtained in the experiments with these high-grade seeds with those secured in the State at large to show the possibilities of beet production in Wisconsin. With such data before the investigator, it is evident that he must be convinced of the fact that it is possible, with proper conditions of seed and culture, to produce a grade of beets of the highest quality in Wisconsin.

NEW YORK.

Most satisfactory results were obtained from the experimental work in the State of New York at Geneva. Two sets of samples were received from the station, representing intervals of about two weeks in harvesting, the first set of samples having been harvested on the 27th of September and the second on the 14th of October. It will be noticed that a marked improvement was secured by postponing the harvest for two weeks, showing that as a rule it is not to be expected that the season for manufacturing in New York should begin before the middle of October. The above table includes also the final harvest, which was made much later in the season, viz, October 29–30, and shows even a greater improvement. The beets from the final harvest were all sent to Washington, and were carefully selected for seed production. The data obtained in this selection are given as the third in the series of analyses. The samples which were grown at the New York station were from seeds of two different qualities: First, commercial seeds, as represented by the Demesmay White Imperial and high-grade commercial Kleinwanzlebener; and, second, seeds grown directly from high-grade mothers, represented by the Vilmorin La Plus Riche, the Vilmorin Improved (Schuyler), and the Original Kleinwanzlebener. The average size of the beets selected for analysis was not quite 20 ounces; the sugar content in most cases was high, and the purity extremely satisfactory. After leaving the beets unharvested until the end of October they were found to have increased their content of sugar very markedly, as will be shown in the table of analyses for the selection of mothers. The encouraging data obtained at the New York station suggests that if the Department should reestablish its experiment stations for the production of high-grade seeds one of them should be placed in this locality.

In the analysis of the beets to be selected as mothers for producing seeds no attempt was made to determine the coefficient of purity, as the amount of pulp removed was only sufficient to determine the percentage of sugar directly therein. It is evident, however, that the purity coefficients of all the different varieties would not have been diminished by perfect maturity, so that they may be regarded as fully equal to the average in each case. In fact, it would be fair to assume that the averages of the final harvest of the most mature beets were slightly above those taken for the average of the three analytical periods of the season. In the discussion of the data obtained by the analysis it must be remembered that the averages in all cases are made upon the total weight of the material entering into the analysis. Not only is this true of each individual sample, but also of the average analyses of the samples. It is evident that this is the one exact method of obtaining average results, and it is only the averages obtained by such a method that have a convincing value.

DATA OF EACH VARIETY.

The White Improved Imperial Élite, grown from commercial seeds gave beets of fair commercial quality. An average weight of 18 ounces, with a content of 15.2 per cent of sugar in the beets and a coefficient of purity of 81.3, would insure a large yield in a well-built and well-operated factory. From the complete harvest, 174 beets were found of the required size, shape, and sugar content to warrant saving for the production of seed. It is evident, however, that this seed would be only of a medium grade commercial quality, and not suited to the improvement of the beet.

Vilmorin La Plus Riche.—This plot gave excellent results throughout. The average size of the beets was the largest of any of the plots grown. The purity coefficients were exceptionally high, and the sugar contents most satisfactory. Two hundred and seven beets grown on this plot, having an average weight of 20 ounces and a mean content of sugar of 18.3 per cent, were selected for seed production. It is evident that the coefficient of purity of this selection must have been at least 86. These mothers will therefore produce seeds of the highest quality, which can subsequently be planted, growing beets for the production of seeds of exceptional properties.

Vilmorin Improved, Schuyler Seed.—This variety is chiefly of interest now because it represents the continuation of the work in seed production which was discontinued four years ago. The seeds evidently have lost in vitality by their long keeping, and the product, therefore, is not as satisfactory as could have been desired. The average sugar content is not exceptionally high, but the purity is excellent. The beets produced from these seeds in another year will doubtless develop some exceptionally high-grade mothers, and thus the strain will be continued. This plot represents the sole surviving result of the three years' experiments at Schuyler, commenced in 1890. Thirty-two beets, with an average weight of 18 ounces and an average content of sugar of 15.7 per cent were put aside for seed production. It is seen, from an inspection of the table, that the coëfficient of purity of this lot was 87 or more. It therefore represents the highest grade of purity of any of the lots.

Vilmorin Improved.—This is a commercial seed, used for planting around the central plots, and has produced a crop of only fair commercial value.

Demesmay.—This is also a commercial seed, obtained directly from the growers in the north of France, and, as will be seen from an inspection of the table, produced a crop of excellent commercial value.

Vilmorin Improved Élite, grown by Dippe Brothers.—This seed represents the improvement in the strain of the Vilmorin beet when cultivated according to the highest scientific principles in Germany. Sixty-four beets grown on this plot, having an average weight of 19 ounces, were selected for mothers. The mean content of sugar in these beets was 18.1. It is evident, also, that the purity was at least 86 per cent. This harvest, therefore, represents a very high grade quality of mothers for continuing the improvement.

High-grade Commercial Kleinwanzlebener.—This variety of seed represents the highest grade of commercial seeds offered to the market. The results of culture show that the tendency of this seed to produce rich beets is extremely well marked. Two hundred and twenty-four beets grown on this plot, with an average weight of 18 ounces, were selected as mothers. The mean content of sugar in these beets was 17.8 per cent, and the purity, as seen by the table, is evidently high. These high-grade commercial seeds, therefore, produce a strain of beets almost as valuable for sugar production as the specially high grade seeds from analyzed mothers.

Original Kleinwanzlebener (Holland.)—This variety of seed represents the Kleinwanzlebener type as cultivated to the highest degree in Holland. The tendency in that country seems to be to the production of a beet of small size and exceptionally high sugar content. Only a few of these high-grade seeds were planted, and this, together with their small size, accounts for the fact that only seven were selected. The mean weight of the seven was 18 ounces, the mean content of sugar therein 19.2, and the coefficient of purity evidently 86 or over. This variety produced the highest content of sugar of any cultivated, but on account of the small size is less to be recommended for general cultivation in this country than some of the other varieties.

Kleinwanzlebener Elite.—This variety represents the specially-selected seeds grown by Dippe Brothers, at Quedlinburg. The beets grow to a fine size, are of good shape, and have excellent qualities to recommend them to the manufacturer. Two hundred and eleven of these beets, having an average weight of 20 ounces, were selected as mothers. The mean content of sugar in these beets was 18.7 per cent, and the coefficient of purity, as will be seen by the table, good.

CLASSIFICATION OF THE BEETS OF EACH VARIETY.

It will be interesting to study the distribution of the beets of each variety according to sugar content. This can be done by means of the following table:

Variety.	Number of beets having contents of sugar from—				Maximum polarizations of individual beets.	Minimum polarizations of individual beets.
	15 to 16 per cent.	16 to 17 per cent.	17 to 18 per cent.	18 per cent and above.		
					Per cent.	*Per cent.*
White Improved Imperial Élite	65	20	23	4	19.0	11.6
Vilmorin La Plus Riche	7	16	32	94	23.4	13.4
Vilmorin Improved, Schuyler Seed	4	8	5	8	18.8	12.4
Demesmay	11	14	5	40	22.0	9.6
Vilmorin Improved Élite (Dippe Brothers)	1	4	5	47	21.6	10.6
High Grade Commercial Kleinwanzlebener	19	30	64	107	22.0	13.6
Kleinwanzlebener (Holland)	0	1	9	50	22.2	18.4
Kleinwanzlebener Élite	6	15	24	165	22.0	14.6

PRESERVATION OF THE MOTHER BEETS.

The spaces in the beets caused by the removal of the diagonal core for analysis were filled with cotton saturated with formaldehyd. The beets thus prepared were placed in silos, where they will remain until March.

GROWTH OF SEED FROM THE MOTHERS ABOVE DESCRIBED.

Since the pollen of the beet is easily transported, it is necessary that each variety of seed be grown in plots entirely removed from any danger of fertilization from other localities. In order to secure this, one of the varieties preserved will be planted, through the courtesy of Mr. William Saunders, superintendent of the garden and grounds, in the Department garden at Washington and arrangements have been made with the following experiment stations to grow one variety each of the remaining beets, viz: Maryland; Ithaca and Geneva, N. Y.; Michigan, Wisconsin, and Iowa. As soon as practicable in the spring the silos will be opened and the beets forwarded to the stations above named for transplanting.

The beets of each variety of different degrees of strength should be planted as far removed as possible from the other classes. For instance, the beets in the grade of 20 per cent of sugar should be planted far enough from other grades of the same variety to prevent intermixing of the pollen. In this way the strain of excellence can be best preserved. The beets which have been saved for mothers are to be divided into classes representing different degrees of saccharine strength, and each of these classes planted separately to produce high grade seed for future use.

NECESSITY OF SEED DEVELOPMENT.

It is highly important for the rapid and safe progress of the beet-sugar industry in this country that attention should be paid to the production of high-grade seeds. We have in the United States such great differences in soils and climatic conditions as to render it evident that a single station for the production of seeds would not be sufficient. Beets of different qualities should be developed in different localities. The character of beets best suited to the fields of New York and Wisconsin, for instance, would not be the ideal plant for the semiarid regions of Nebraska. On the other hand, it is evident that beets grown in an arid region, as, for instance, Chino and other valleys of California, without irrigation and with scarcely any rainfall, should have a longer tap root than those grown in localities where rainfall is abundant or irrigation is practiced. It seems plain, therefore, that three, if not four, stations should be established, and in order that this work may be conducted under uniform methods these stations should be established and maintained by the Department of Agriculture.

One of these stations should be located in an area of average rainfall and ordinary meteorological conditions as presented, for instance, by the States of New York and Michigan.

The second station should be established in a locality where a deficient rainfall is to be expected, and where the vicissitudes attending meteorological changes are the greatest, as, for instance, in South Dakota or Nebraska.

The third station should be established in a region where irrigation is practiced, as, for instance, in Colorado, New Mexico, or Utah.

A fourth station should be devoted to the development of a beet best suited to arid regions where irrigation is not practiced, as, for instance, in the coast valleys of California.

It is only by a careful, systematic, and scientific development of beets suited to these different localities that we can expect to promote in the most favorable manner the development of the beet sugar industry in the United States. It is evident that the continuation of the experiments which have been conducted by the Department of Agriculture for so many years in the analysis of beets and in the delimitation of areas suited to beet culture should now be supplemented by a more rigid scientific attempt to develop beets of characteristics best suited to the four typical localities which have been specified above. The maintenance of a small experiment station entirely competent to accomplish this work in each of the localities mentioned would not require a very great outlay of money and would result in the greatest possible good to the industry.

STATISTICS OF AMERICAN BEET-SUGAR PRODUCTION.

The information contained in the following table has been obtained through the courtesy of the beet-sugar factories:

Statistics of the production of beet sugar in the United States for the year 1897.

Number of factories in operation	9
Number of acres of beets harvested	41,272
Approximate average price paid for beets	$4.10
Approximate average per cent of sugar in the beets	14.49
Total pounds of granulated sugar made	90,060,470
Total pounds of raw sugar made	431,200
Granulated sugar obtained per cent beets	11.56
Raw sugar obtained per cent beets	0.06
Total sugar obtained per ton (2,000 pounds) of beets ... pounds	232.4

Statistics of individual factories for the year 1897.

Name of factory and location.	Beets harvested.	Beets harvested.	Price paid per ton of beets.	Time the machinery was in operation.	Sugar content of the beets.	Total output of granulated sugar.
	Acres.	*Tons.*		*Days.*	*Per ct.*	*Pounds.*
Alameda Sugar Co., Alvarado, Cal	4,808	48,773	$4.00	90	14.20	10,198,648
Chino Valley Beet Sugar Co., Chino. Cal	9,678	97,197	(*a*)	151	15.10	24,303,122
First New York Beet Sugar Co., Rome, N. Y	700	4,325	5.00	45	(*b*)	*c*765,700
Oxnard Beet Sugar Co., Grand Island, Nebr	4,282	38,607	(*d*)	(*d*)	12.90	6,798.300
Los Alamitos Sugar Co., Los Alamitos, Cal	2,800	29,542	4.16	105	15.73	6,017,900
Norfolk Beet Sugar Co., Norfolk, Nebr	4,029	36,113	(*d*)	(*d*)	13.60	7.941.400
Pecos Valley Beet Sugar Co., Eddy, N. Mex	1,600	5,700	4.00	38	14.00	1,020.000
Utah Beet Sugar Co., Lehi, Utah	3,000	18,500	4.25	56	13.20	3,670,600
Western Beet Sugar Co., Watsonville, Cal	10,375	110,878	4.00	104	15.00	29.776,000
Total	41,272	389,635				90,491,670

a $3.50 per ton for 12 per cent beets, and 25 cents per ton for each per cent above 12. The Chino factory employed a saccharate process.
b Red beets, 5½ to 12 per cent sugar; white beets, 13 to 17 per cent sugar. Average analysis not reported.
c 431,200 pounds raw sugar are included.
d Not reported.

REMARKS ON THE BEET-SUGAR STATISTICS FOR 1897.

The past season was not very favorable to the production of beets in several localities in California and in New Mexico and Utah. Insufficient rain in California at the time of planting resulted in a smaller acreage being planted to beets and in a small yield of roots per acre. The great shortage in the crop reduced the quantity of sugar produced in California below that of the previous year, notwithstanding the fact that the new factory at Los Alamitos was operated and that at Chino increased its output.

The first New York beet-sugar factory was somewhat unfortunate in the varieties of beets selected. The red beets contained very little sugar, and undoubtedly decreased the output below what it should have been under favorable conditions. The white beets were of satisfactory sugar content. As may be noted by an examination of this report of the experiments made in the State of New York during the past season, that State is capable of producing beets of very great richness.

The shortage in the output of sugar is to some extent due to a decreased acreage at Lehi, Utah, and at Watsonville, Cal., these two factories having a larger crop in 1896 than they could work to advantage. In 1896 the factory at Watsonville produced nearly 20,000 short tons of sugar from approximately 150,000 tons of beets, and the past year 14,888 short tons from 110,878 tons of beets. The total production for the country shows an increase of approximately 5,000 tons in 1897 over that of 1896. The increase in the output of sugar next season, should more favorable conditions prevail in California, will be very large, since eight new factories, having a daily capacity of approximately 6,700 tons of beets, will be in operation.

The output is reported in the tables in pounds of granulated sugar, since but one factory marketed raw sugar. The quantity of raw sugar produced does not materially modify the statistics of the production.

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BULLETIN No. 53.

U. S. DEPARTMENT OF AGRICULTURE.
DIVISION OF CHEMISTRY.

CHEMICAL COMPOSITION
OF THE
CARCASSES OF PIGS.

BY

H. W. WILEY,
CHIEF OF THE DIVISION OF CHEMISTRY.

WITH THE COLLABORATION OF

E. E. EWELL, W. H. KRUG, T. C. TRESCOT,
AND OTHERS.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1898.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Division of Chemistry,
Washington, D. C., June 27, 1898.

Sir: I transmit herewith for your inspection and approval the manuscript containing the results of our investigations, undertaken at your suggestion, on the chemical composition of the carcasses of pigs grown at the agricultural experiment station of Iowa.

The scope of these investigations has extended so much farther than was at first anticipated as to render the results thereof worthy of publication as a separate bulletin of this Division. A study of the character of the data obtained will reveal at once their great importance, both from a scientific point of view and as a basis for economic studies.

The carcasses, as received by us, represented practically only those portions of the whole carcass which are subjects of commerce. The blood, hair, entrails, heads, kidneys, and kidney fats of the animals were removed before they were transmitted to us. The data, therefore, do not represent the composition of the whole animal, but what, perhaps, is of equal importance, the composition of the animal as sent into commerce for food.

In view of the great importance of investigations of this kind, I would venture to suggest that when the facilities for work in the chemical laboratories are extended by the completion of the new building now in course of construction, it would be well for you to direct that further studies of this kind be undertaken. It would be advisable, if possible, that in studies of this kind, the animals be slaughtered at or near the point where the chemical examination is to be made, or if this be not convenient, that a representative of the Chemical Division be present at the time of the slaughtering for the purpose of ascertaining the quantities of blood, hair, and excreta from the different animals and obtaining representative samples thereof for chemical examination.

I have the honor to be, respectfully,

H. W. Wiley,
Chief of Division.

Hon. James Wilson, *Secretary.*

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CHEMICAL COMPOSITION OF THE CARCASSES OF PIGS.

ANALYTICAL WORK.

INCEPTION OF THE INVESTIGATION.

Following instructions received from the Secretary of Agriculture, the Division of Chemistry, in November, 1897, undertook a study of the chemical composition of the carcasses of pigs. These pigs were grown at the Iowa Agricultural Experiment Station under standard conditions of diet, and a comparison of their carcasses reveals, therefore, the influence of breed and heredity on the character of the meat. In the following correspondence will be found the data connected with the history of the animals before they were delivered to the Division of Chemistry.

CORRESPONDENCE.

EXPERIMENT STATION, IOWA AGRICULTURAL COLLEGE,
Ames, Iowa, October 8, 1897.

MY DEAR SIR: We have, as you are aware, a very interesting and instructive experiment nearing completion, in which we have grown carefully selected representatives of six of the leading breeds of hogs since birth in lots of ten each. These pigs are now weighing nearly 200 pounds, and will be forwarded to market for the test in determining the relative market value and the results in slaughtering and on the block, and the meat will be carefully compared and rated by experts. This experiment includes the Poland China, Berkshire, Duroc Jersey, Chester White, Tamworth, and Yorkshire. It has occurred to us that a careful and exhaustive chemical analysis of representative carcasses selected from each lot after slaughtering would be a valuable feature of this investigation, and I write to know if the Department of Agriculture can not cooperate with us in this work. We will gladly furnish you such material as may be needed and in any form desired. I will be glad to hear from you in reference to this point, and trusting that such arrangements can be made, I am,

Very truly, yours,

C. F. CURTISS.

Hon. JAMES WILSON,
Secretary of Agriculture, Washington, D. C.

EXPERIMENT STATION, IOWA AGRICULTURAL COLLEGE,
Ames, Iowa, October 29, 1897.

MY DEAR MR. WILSON: Your esteemed favor of the 26th instant is at hand and I note what you say about cooperation of the Department with us in our hog-feeding experiments. The final weighing of the pigs will be taken Monday, and they will arrive in Chicago Tuesday morning. I have arranged to place them on exhibition in the Coliseum Building during the fat-stock show, and will take them to the stock yards for slaughter and block tests immediately following. After the carcasses have been cooled down I will have a committee of the expert meat dealers select one or two representative carcasses from each lot and forward to Dr. Wiley for investigation. Probably it will be a week or ten days before the carcasses reach Washington.

Very truly, yours,

C. F. CURTISS.

Hon. JAMES WILSON,
Secretary of Agriculture, Washington, D. C.

EXPERIMENT STATION, IOWA AGRICULTURAL COLLEGE,
Ames, Iowa, November 13, 1897.

DEAR SIR: Your valued favor of the 3d instant came to hand while I was in Chicago having the slaughter test made of the pigs used in our experiments. Owing to the machinery used in the packing house where the hogs were killed, it was not practicable to obtain the weight of the hair, and the blood could not be collected and weighed without considerable difficulty. I had taken this matter up with Swift & Co. before receiving your letter, but was obliged, under the circumstances, to omit these items. The weight of the intestines and other internal organs was obtained. I returned this morning from superintending the block test yesterday, and have had a good representative carcass from each lot selected and cut according to the prevailing method of cutting pork for the American market, and each piece weighed and properly tagged, giving commercial names. I think, however, that the names are appended only to one set of cuts, but you will be able to apply these names to corresponding cuts of the other carcasses. I have directed Swift & Co. to forward this material to you, including all scraps and trimmings made in cutting, and to deliver it to you at their earliest convenience. They stated that they would probably have one of their refrigerator cars leaving for Washington to-day, and that they would notify you upon its arrival at their house in Washington and deliver the pork upon your order.

Very truly, yours,

C. F. CURTISS.

Dr. H. W. WILEY,
Chief of Division of Chemistry, Washington, D. C.

BREEDS OF HOGS STUDIED.

In accordance with the plan outlined in the above letters, on November 16, 1897, Swift & Co., of Chicago, shipped to the Department of Agriculture the carcasses of eight pigs which had been slaughtered under the direction of Professor Curtiss. These pigs were of the following breeds, each animal being designated by a number, which is used for its identification throughout the following pages:

1, Berkshire; 2, Tamworth; 3, Chester White; 4, Poland China; 5, Duroc Jersey; 6, Duroc Jersey; 7, Duroc Jersey; 8, Yorkshire.

On the receipt of the animals in Washington, they were immediately placed in cold storage, where they were kept until they were removed one by one for the purpose of dissecting and preparing the samples for analysis.

The expert labor of assistants in the meat markets of Washington was secured for the purpose of properly dissecting the animals and separating each portion as carefully as possible from the others. The greatest care was exercised in this preliminary work, inasmuch as the value of the analytical data rests largely on the proper preparation of the materials for examination.

PREPARATION OF SAMPLES FOR ANALYSIS.

The methods of preliminary treatment, together with the methods of chemical analysis employed, are detailed in the following pages. Before leaving Chicago each animal was cut up into the following cuts, the head, leaf lard, and kidneys being retained in Chicago:

Two American clear backs; two clear bellies; two short-cut hams; two New York shoulders; four feet; spare ribs; tenderloins; neck bones; back bones; trimmings, fat and lean; tail.

These cuts were all weighed on leaving Chicago, and again in Washington just preceding their analysis. All of these weights appear in the accompanying tables, pages 15 to 64. The weighings in Washington were made on a large counter scale for the larger cuts, and on a torsion balance in the case of the smaller cuts. The cuts were then separated into the following parts: Meat (including both fat and lean), bones. marrow, skin, spinal cord, tendons, and hoofs.

Each of the parts, except the meat, was carefully weighed, and the weight of the meat obtained by subtracting the sum of the other weights from the total weight of the cut before cutting up.

SAMPLES OF MEAT.

The meat obtained from all of the cuts of the same kind in each animal was passed through a meat chopper two or more times in order to bring the sample into a finely divided condition. A weighed portion was then placed in a weighed casserole or evaporating dish. A glass rod was also weighed with the casserole. In the case of small samples, as the tenderloins, the entire quantity was taken; in the case of the larger cuts, from 400 to 600 grams of the fresh material were taken for the preparation of the air-dried sample. After the removal of these portions for the preparation of the air-dried sample, duplicate portions of 5 grams each were weighed for the direct determination of water and fat. These small samples were placed in aluminum dishes and dried in vacuo for six hours at 105 degrees. The residues were extracted for sixteen hours with ether, and the extracts dried in an air bath at 100 degrees. These direct determinations of fat and water were used as a check on the data obtained in the preparation of the air-dry samples. The larger portions, which had been weighed out as described above for the preparation of the air-dried samples, were placed in a steam oven at a temperature of 100 degrees or slightly more and heated until the fat had thoroughly separated, when the fat was poured off into a flask, care being taken not to pour with it any of the aqueous portion of the meat which formed a layer underneath the fat. After as much fat had been poured off as was possible, the drying was continued in the steam oven until the weight had become approximately constant. As there was still too much fat contained in the samples to permit of their being powdered, it was necessary to extract them with ether before proceeding with the grinding. The extraction with ether was done in the following way.

Large funnels were placed in hot-water jackets, and in the funnels were placed filters of parchmentized paper. The smooth surface of this paper greatly facilitated the removal of the insoluble residue of the sample. The portion of fat from each sample, which had been poured off as above described, was first passed through this filter and collected in a weighed flask and its weight taken. The remainder of the sample was then treated with ether and brought on to the filter and the washing with ether continued until the fat was sufficiently removed for the sample to be easily pulverized and brought into proper condition for subsequent analytical operations. The ether solution of the fat was also received in a weighed flask. The ether was removed by distillation and the residue heated to constant weight and weighed. There was considerable annoyance from the breaking of the flasks containing the fat while on the steam bath. When there was an evident loss of fat, the fat determinations were recorded as lost. When the flask was discovered with only a slight crack, the results are marked in the following tables with a (?) mark. The portion of the meat on the filter was returned to the dish which had previously contained it, and was again dried to approximately constant weight and then left exposed to the air for at least twenty-four hours in order to establish an equilibrium of its moisture content. The weight of the sample was then taken and recorded as the air dry weight of the material.

The difference obtained by subtracting the sum of the weights of the air-dry material, fat obtained by pouring, and fat obtained by ether extraction from the original weight of the sample taken was recorded as the weight of water removed in the preparation of the sample. From these data were calculated:

Percentage of water removed in the preparation of the sample;

Percentage of fat removed in the preparation of the sample; and

Percentage of air-dry sample obtained.

All three of these were expressed in percentages of the original material.

The air-dry samples were then ground, so as to pass a sieve having circular perforations 1 millimeter in diameter, and placed in closely stoppered bottles.

SAMPLES OF SKIN.

The portions of skin obtained from each cut were united to make one sample of skin for the entire animal. The united sample of skin from each pig was passed through the meat chopper, and the finely divided and thoroughly mixed sample was treated in exactly the same way as described above for the samples of meat. The samples of meat from each cut were kept separate, however, while only one sample of skin was prepared for each animal.

SAMPLES OF BONES AND OF MARROW.

The bones from each cut were weighed and were united to make one sample of bones from each animal. They were then chopped up into bits about 1 inch long and the marrow removed. The marrow was weighed in a tared dish and treated as samples of meat, except that no determinations of moisture and fat were made in the original material. The fragments of the bones after the removal of the marrow were thoroughly mixed, and about half the total quantity was weighed in a tared dish and dried to approximately constant weight in a large agate-ware pan. After standing for from twenty-four to forty-eight hours exposed to the air, the weight was again taken and recorded as the weight of air-dried bones equivalent to the portion of fresh bones taken for the drying. The sample thus obtained was passed through a bone cutter, such as is used for poultry food, and from this, 500-gram portions were weighed and treated with petroleum ether by decantation for the removal of the fat. The solutions of fat were very difficult of filtration, hence were allowed to stand for some time for the almost complete subsidence of the solid matter contained in them, when they were carefully siphoned off and evaporated and the weight of the fat contained in them determined. The residues were again dried and exposed to the air for the establishment of the equilibrium of moisture content, and again weighed, the weight obtained being recorded as the weight of the air-dry, extracted bones. The samples thus obtained were submitted to analysis, and the determinations made are recorded below, all percentages being calculated back to the original material by use of the data obtained in the preparation of the sample.

SAMPLES OF SPINAL CORD.

The spinal cord was carefully separated from the backbones and neck bones, and the material thus obtained united to make one sample of spinal cord for each animal. This sample was prepared for analysis in the manner described for meats, but it was not practicable to make a direct determination of fat and moisture in the original sample.

SAMPLES OF TENDONS.

It was not practicable to separate the tendons from other cuts of the animal than the feet and legs, that is, the portion sent to the laboratory under the name of "feet." The tendons were treated in the same manner as the spinal cord.

SAMPLES OF HOOFS.

The hoofs were separated and weighed. In some cases some of the hoofs had been removed in the process of slaughtering and dressing the animal. In these cases the whole weight of hoofs was corrected for the deficiency by using the average weight of one hoof for the weight of each of the remaining hoofs. The hoofs were weighed and dried in the steam oven and then left to assume their air-dry content of moisture. They were then ground and submitted to analysis as described below for the other parts.

METHODS OF ANALYSIS USED.

On the samples thus prepared the following determinations were made:

Water, fat, ash, total nitrogen, nitrogen insoluble in hot water, nitrogen soluble in hot water but precipitated by bromin, and lecithin.

For the determination of MOISTURE and FAT 2-gram portions were dried for six hours in a vacuum oven for the determination of water, and the residues were extracted for sixteen hours with ether for determination of the fat.

For TOTAL NITROGEN duplicate portions of one-half gram of the air-dried sample were treated by the Gunning method.

For INSOLUBLE PROTEID NITROGEN 1-gram portions were washed with ether by decantation, using about 50 to 100 c. c. of ether for each sample, and decanting the ether through filters which were afterwards used to receive the portions of the sample insoluble in hot water. After allowing the ether to evaporate the samples were next treated with hot water, this washing being also by decantation, and the total amount of water used being 300 to 400 c.c., the residues being brought on the filter with the last portion of the water. The filters and residues were then treated by the Gunning method.

The filtrates from the insoluble portions of the meat were received in Kjeldahl flasks and were used for the determination of the NITROGEN PRECIPITATED BY BROMIN (GELATINOIDS).[1] After acidulation with two or three drops of strong hydrocloric acid, about 2 c. c. of bromin were added and the flasks vigorously shaken. If this quantity of bromin was all taken up more was added and the shaking repeated until a globule of about ½ c. c. of bromin was left in the flask, and the liquid above it was thoroughly saturated with bromin. The mixture was then allowed to stand until the next morning, when the supernatant liquor was passed through a filter and the residue in the flask washed by decantation, the globule of undissolved bromin in the flask saturating the wash water with bromin, so that it was unnecessary to use bromin water for the washing. The filter containing the residue was then returned to the same flask in which the precipitation had taken place and treated by the Gunning method.

The percentage of nitrogen in the form of FLESH BASES was found by subtracting the sum of the numbers representing insoluble nitrogen and nitrogen precipitated by bromin from the number representing the percentage of total nitrogen. The percentage of flesh bases was obtained by multiplying the percentage of nitrogen in that form by 3.12. For the other forms of nitrogen, the factor 6.25 was used.

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[1] See Appendix, page 79.

For the determination of LECITHIN,[1] 20 grams of the material were allowed to stand for twenty-four hours at from 35° to 40° C. with 200 c. c. of a mixture of equal parts of ether and 95 per cent alcohol. The material was then filtered and the residue extracted repeatedly with the same solvent. The filtrate and washings were evaporated to dryness on the water bath in a platinum dish. The residue was fused with mixed carbonates (equal parts of sodium and potassium carbonates). A little potassium nitrate was added during the fusion. The flux was dissolved in hot water, filtered, and the phosphoric acid determined in the filtrate by the Kilgore-Pemberton volumetric method. The lecithin was calculated as distearyl lecithin, which contains 8.789 per cent P_2O_5.

RESULTS OF THE INVESTIGATION.

DESCRIPTION OF TABLES.

The results of this work are presented in the accompanying tables. The first fifty-six tables are in seven groups. Each group gives in a separate table data for each of the eight pigs used.

Table 1 shows the weights of the whole cuts as obtained in Chicago and Washington, results of the direct determination of water and fat in the meat from each cut, and data in regard to the preparation of the air-dry sample of the meat from each cut.

Tables 2 and 3 show the weights of meat, bones, skin, etc., obtained from each cut, the total for the whole animal, and also the percentages of meat, bones, skin, etc., in each animal. These sheets also contain the data in regard to the preparation of the sample of bones, marrow, skin, spinal cord, tendons, and hoofs.

Tables 4 and 5 show all the analytical data, including the data actually obtained on the air-dry material, and also the corresponding data expressed in terms of the original material.

In Table 6 the analytical data have been collected in condensed form for convenience of reference.

In Table 7 are presented the weights of water, fat, nitrogenous substances, lecithin and ash in the meat of each entire animal, and also the weights and average percentages of each of these substances for the entire animal, including all its parts—meat, bones, skin, etc. These data were obtained by multiplying the weight of the meat from each cut by the percentage of each one of the constituents, finding the total, and dividing by the number representing the total weight of the meat of the entire animal. The same method was employed for the bones, marrow, skin, etc. Thus there were obtained the total weight of water for each animal, total weight of fat, etc. These total weights, divided by the weight of the entire animal, gave the average percentages of the various constituents of the entire animal.

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[1] Principles and Practice of Agricultural Analysis, Vol. III, p. 430.

In Tables 8 A to 8 K, have been placed the data which show the chemical composition of the meat of each cut of each pig.

In Table 9 has been placed the average composition of the meat of each animal.

Table 10 contains similar data for the bones of each animal, Table 11 for the marrow, Table 12 for the skin, Table 13 for the spinal cord, Table 14 for the tendons, and Table 15 for the hoofs. In Table 16 will be found a résumé of the weights of each cut, and also of each entire animal, as found in Chicago and found in Washington, the results being stated in both grams and pounds.

Table 17 shows the percentages of each of the parts for each animal, stated in percentages of the entire dressed animal, less the head, leaf lard, and kidneys.

Table 18 shows the proportion of water, fat, nitrogenous substances, lecithin and ash in each of these animals, stated in percentages of the entire dressed animal, less the head, leaf lard, and kidneys.

There is one obvious omission in the data presented in the tabulation just described. The absence of any information in regard to the manner of the feeding of the pigs has made it impossible to group them properly and make proper averages of the percentages of the various constituents in the animals which have received the same rations and other treatment previous to their slaughter. This missing data will be found in the forthcoming full report of Professor Curtiss, of the Iowa Agricultural Experiment Station, which should be consulted with the data herewith submitted.

TABLE NO. 1.—*Weights of whole cuts and data relating to the preparation of air-dry samples.*

PIG No. 1.—BERKSHIRE.

Serial No. of air-dry meats.	Names of cuts.	Weights of whole cuts.						Direct determinations on original material.		Preparation of air-dry samples.							
		Chicago.			Washington.			Water.	Fat.	Weight of fresh sample.	Air-dry sample of original material.	Weight of air-dry sample after extraction.	Weight of fat.	Air-dry sample plus fat.	Weight of water removed.	Removed in preparation of sample.	
																Water.	Fat.
		Lbs.	*Oz.*	*Grams.*	*Lbs.*	*Oz.*	*Grams.*	*Per ct.*	*Per ct.*	*Grams.*	*Per ct.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Per ct.*	*Per ct.*
	2 American clear backs	35½	0	16,102.8	34	6	15,592.5										
16667	Meat							31.33	58.21	833.0	13.16	109.6	458.0	567.6	265.4	31.86	54.98
	2 clear bellies	19½	0	8,845.2	19	4	8,731.8										
16669	Meat							36.09	52.69	741.2	14.33	106.2	362.1	468.3	272.9	36.82	48.84
	2 short-cut hams	23½	0	10,659.6	23	5	10,574.6										
16671	Meat							60.29	22.19	532.5	22.95	122.2	88.3	210.5	322.0	60.47	16.58
	2 New York shoulders	20½	0	9,298.8	20	10	9,395.5										
16673	Meat							54.97	29.01	532.5	17.65	94.0	152.9	246.9	285.6	53.64	28.71
	4 feet (7 hoofs)	*a* 3½	0	*b* 1,594.2			*b* 1,514.1										
16675	Meat							59.78	17.04	221.1	25.10	55.5	33.7	89.2	131.9	59.66	15.24
	Spareribs	5	0	2,268.0			2,212.0										
16677	Meat							50.33	30.05	359.9	20.81	74.9	98.6	173.5	186.4	51.79	27.39
16679	Tenderloins	1	0	453.6			470.8	67.14	9.14	427.9	27.11	116.0	26.6	142.6	285.3	66.67	6.21
	Neck bones	2	0	907.2			842.5										
16680	Meat							53.82	28.72	390.6	20.02	78.2	100.5	178.7	211.9	54.25	25.73
	Backbones	3½	0	1,587.6			1,580.0										
16682	Meat							51.89	27.16	397.5	22.24	88.4	102.1	190.5	207.0	52.08	25.69
	Trimmings	18	0	8,164.8	16	9	7,512.8										
16684	Meat							29.68	62.00	783.7	9.72	76.3	479.2	555.5	228.2	29.11	61.17
	Tail	¼	0	113.4			363.0										
16686	Meat							23.99	69.25	199.2	8.73	17.4	134.7	152.1	47.1	23.64	67.62
	Total	132¼	0	*b* 59,995.2			58,789.6										

a Missing hoof, 6.6 grams.

b Corrected for missing hoof.

TABLE NO. 1.—*Weights of whole cuts and data relating to the preparation of air-dry samples*—Continued.

PIG NO. 2.—TAMWORTH.

Serial No. of air-dry meats.	Names of cuts.	Weights of whole cuts.						Direct determinations on original material		Preparation of air-dry samples.							
		Chicago.			Washington.			Water.	Fat.	Weight of fresh sample.	Air-dry sample of original material.	Weight of air-dry sample after extraction.	Weight of fat.	Air-dry sample plus fat.	Weight of water removed.	Removed in preparation of sample.	
																Water.	Fat.
		Lbs.	*Oz.*	*Grams.*	*Lbs.*	*Oz.*	*Grams.*	*Per ct.*	*Per ct.*	*Grams.*	*Per ct.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Per ct.*	*Per ct.*
	2 American clear backs	41	0	18,597.6	40	8	18,370.8										
16696	Meat							29.13	61.76	786.0	10.48	82.4	377.6	460.0	326.0	41.48	48.04
	2 clear bellies	20	0	9,072.0	19	9	8,873.6										
16698	Meat							32.74	59.06	779.4	12.12	94.5	426.4	520.9	258.5	33.17	54.71
	2 short-cut hams	26	0	11,793.6	25	12	11,680.2										
16700	Meat							57.93	24.45	617.4	19.99	122.9	Lost.				
	2 New York shoulders	21	0	9,525.6	20	12	9,412.2										
16702	Meat							35.07	29.98	827.6	20.36	168.5	Lost.				
	4 feet (6 hoofs)	*a* 4½	0	*b* 2,057.3			*b* 1,974.1										
16704	Meat							58.66	21.23	331.7	23.85	79.1	58.9	138.0	193.7	58.39	17.76
	Spareribs	5	0	2,268.0			2,132.7										
16706	Meat							49.58	19.79	701.0	19.67	187.9	225.8	363.7	337.3	48.12	32.21
16708	Tenderloins	1	0	453.6			528.2	63.90	13.71	420.3	24.12	101.4	48.3	149.7	270.6	64.38	11.49
	Neck bones	2	0	907.2			886.0										
16709	Meat							54.21	27.14	322.7	20.95	67.6	79.6	147.2	175.5	54.38	24.67
	Backbones	4	0	1,814.4			1,840.0										
16711	Meat							50.45	30.33	423.3	20.98	88.8	124.2	213.0	210.3	49.68	29.34
	Trimmings	18¼	0	8,278.2	16	10	7,541.1										
16713	Meat							27.39	66.33	869.8	10.53	91.6	531.7	623.3	246.5	28.34	61.13
	Tail	¼	0	113.4			707.5										
16715	Meat							29.38	61.54	474.2	9.53	45.2	120.0	165.2	309.0	25.31	65.16
	Total	143	0	*b*64,880.9			63,946.4										

PIG NO. 3.—CHESTER WHITE.

Serial No. of air-dry meats.	Names of cuts.	Chicago Lbs.	Chicago Oz.	Chicago Grams.	Washington Lbs.	Washington Oz.	Washington Grams.	Direct determinations Water.	Direct determinations Fat.	Weight of fresh sample.	Air-dry sample of original material.	Weight of air-dry sample after extraction.	Weight of fat.	Air-dry sample plus fat.	Weight of water removed.	Removed Water.	Removed Fat.
	2 American clear backs	36	0	16,329.6	35	12	16,216.2										
16609	Meat							23.72	70.16	1,094.3	10.09	110.5	(?)197.2	307.7	786.6	71.88	18.02
	2 clear bellies	21	0	9,525.6	21	0	9.525.6										
16611	Meat							29.40	62.23	1,027.0	9.81	100.7	614.9	715.6	311.4	30.32	59.87
	2 short-cut hams	20	0	9,072.0	19	15½	9,057.8										
16613	Meat							53.41	29.99	628.4	24.30	152.7	145.7	298.4	330.0	52.51	23.19
	2 New York shoulders	21	0	9,525.6	20	13	9,440.5										
16615	Meat							49.16	37.62	762.2	17.75	135.3	Lost.				

	4 feet (4 hoofs)	c2½	0	[b]1,152.5			[b]1,236.9										
16617	Meat							53.05	26.74	144.4	20.71	29.9	37.5				
	Spareribs	3	0	1,360.8			1,409.0										
16619	Meat							53.46	27.14	478.8	26.69	127.8	99.9	227.7	251.1	52.44	30.87
16621	Tenderloins	1	0	453.6			453.6	66.75	11.97	435.5	25.88	112.7	39.9	152.6	282.9	64.96	9.16
	Neck bones	1½	0	680.4			683.7										
16622	Meat							54.19	27.04	347.1	19.30	67.0	96.3	163.3	183.8	52.96	27.74
	Backbones	2½	0	1,134.0			1,172.6										
16624	Meat							50.82	31.03	481.3	19.39	(93.3)	147.2	240.5	240.8	50.03	30.58
	Trimmings	27	0	12,247.2	15	12	7,144.2										
16626	Meat							19.17	76.04	992.5	7.20	71.5	(?)700.6	772.1	220.4	22.21	70.59
	Tail	¼	0	113.4			740.2										
16628	Meat							15.66	79.69	553.9	5.65	31.3	Lost.				
	Total	135¾	0	[b]61,594.7			57,080.3										

PIG No. 4.—POLAND CHINA.

	2 American clear backs	40	0	18,144.0	38	12	17,577.0										
16638	Meat							26.13	66.33	954.0	9.68	92.3	(?)582.9	675.2	278.8	29.22	61.10
	2 clear bellies	24	0	10,886.2	23	10	10,716.1										
16640	Meat							29.22	62.65	820.5	9.43	77.4	493.8	571.2	249.8	30.38	60.19
	2 short-cut hams	26	0	11,793.6	25	14	11,736.9										
16642	Meat							53.14	31.32	543.1	17.00	92.3	157.7	250.0	293.1	53.97	29.03
	2 New York shoulders	24	0	10,886.2	23	7	10,631.1										
16644	Meat							51.72	33.74	557.5		103.7	Lost.				
	4 feet (8 hoofs)	3	0	1,360.8			1,359.0										
16646	Meat							47.97	33.32	203.7	19.57	39.8	63.6	103.4	100.3	49.23	31.20
	Spareribs	5	0	2,268.0			1,969.5										
16648	Meat							52.95	29.55	503.3	22.03	110.9	(?) 112.9	223.8	279.5	55.53	22.44
16650	Tenderloins	1	0	453.6			419.8	66.88	11.58	392.9	26.80	105.3	28.9	134.2	258.7	65.85	7.36
	Neck bones	1½	0	680.4			815.6										
16651	Meat							53.74	30.08	432.1	19.37	83.7	114.7	198.4	233.7	54.08	26.55
	Backbones	3	0	1,360.8			1,315.5										
16653	Meat							51.26	30.98	452.2	21.21	95.9	(?) 136.3	232.2	220.0	48.65	30.14
	Trimmings	21¼	0	9,639.0	20	0	9,072.0										
16655	Meat							21.96	72.19	950.0	8.05	76.5	663.2	739.7	210.3	22.14	69.81
	Tail	¼	0	113.4			760.0										
16656	Meat							16.56	78.83	570.0	6.41	36.5	441.5	478.0	92.0	16.15	77.44
	Total	149	0	67,586.4			66,372.5										

[a] Missing hoofs, 16.1 grams.

[b] Corrected for missing hoofs.

[c] Missing hoofs, 18.5 grams.

TABLE No. 1.—*Weights of whole cuts and data relating to the preparation of air-dry samples*—Continued.

PIG No. 5.—DUROC JERSEY.

Serial No. of air-dry meats.	Names of cuts.	Weights of whole cuts.						Direct determinations on original material.		Preparation of air-dry samples.							
		Chicago.			Washington.			Water.	Fat.	Weight of fresh sample.	Air-dry sample of original material.	Weight of air-dry sample after extraction.	Weight of fat.	Air-dry sample plus fat.	Weight of water removed.	Removed in preparation of sample.	
																Water.	Fat.
		Lbs.	*Oz.*	*Grams.*	*Lbs.*	*Oz.*	*Grams.*	*Per ct.*	*Per ct.*	*Grams.*	*Per ct.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Per ct.*	*Per ct.*
	2 American clear backs	39½	0	17,917.2	39½	0	17,917.2										
16579	Meat							20.75	73.25	1,086.1	9.37	101.8	Lost.				
	2 clear bellies	24	0	10,886.4	24⅛	0	10,943.1										
16581	Meat							28.35	64.67	989.5	11.71	115.8	589.1	704.9	284.6	28.77	59.52
	2 short-cut hams	21	0	9,525.6	21	0	9,525.6										
16583	Meat							49.57	35.73	1,213.3	21.39	259.5	350.7	610.2	603.1	49.71	28.90
	2 New York shoulders	19½	0	8,845.2	19	13	8,987.0										
16585	Meat							44.16	43.74	703.3			293.1				41.67
	4 feet (7 hoofs)	*a* 2½	0	*b* 1,137.9			*b* 1,255.4										
16587	Meat							54.16	26.19	102.3	23.86	23.9	23.8	47.7	54.6	53.37	23.27
	Spareribs	3½	0	1,587.6			1,612.0										
16589	Meat							53.89	27.08	604.7	22.23	134.4	147.5	281.9	322.8	53.38	24.39
16591	Tenderloins	1	0	453.6			348.5	67.39	10.55	315.0	28.54	89.9	19.3	109.2	205.8	65.34	6.12
	Neck bones	1½	0	680.4			784.0										
16592	Meat							52.83	29.61	395.8	19.46	77.0	114.1	191.1	204.7	51.71	28.83
	Backbones	3	0	1,360.8			1,438.0										
16594	Meat							52.96	29.47	577.5	25.94	149.8	151.2	301.0	276.5	47.88	26.18
	Trimmings	20¼	0	9,185.4	19	11	8,930.3										
16596	Meat							19.57	74.46	979.2	6.80	66.5	718.7	785.2	194.0	19.81	73.39
	Tail	¼	0	113.4			683.0										
16598	Meat							11.13	85.20	532.8	4.70	25.0	447.4	472.4	60.4	11.83	83.97
	Total	136	0	*b*61,693.5			62,424.1										

PIG No. 6.—DUROC JERSEY.

	2 American clear backs	45	0	20,412.0	44	8	20,185.2										
16725	Meat							20.74	74.09	740.1	6.99	51.7	541.5	593.2	146.9	19.85	73.16
	2 clear bellies	32½	0	14,742.0	32	11	14,827.1										
16727	Meat							2.41	72.20	793.0	8.30	65.8	456.7	522.5	270.5	34.11	57.59
	2 short-cut hams	27	0	12,247.2	26	14	12,190.5										
16729	Meat							42.08	45.54	671.3	27.63	185.5	245.9	431.4	239.9	35.74	36.68
	2 New York shoulders	22	0	9,979.2	22	2	10,035.9										
16731	Meat							38.62	50.66	544.6	12.91	70.3	264.0	334.3	210.3	38.61	48.48

	4 feet (8 hoofs)	3½	0	1,587.6			1,547.2										
16733	Meat							49.65	31.99	292.1	21.84	63.8	81.8	145.6	146.5	50.16	28.00
	Spareribs	4	0	1,814.4			1,612.2										
16735	Meat							48.50	33.45	490.7	22.09	108.4	144.0	252.4	238.8	48.56	29.35
16737	Tenderloins	½	0	226.8			421.3	62.50	14.91	377.6	26.77	101.1	41.1	142.2	235.4	62.34	10.89
	Neck bones	2	0	907.2			892.6										
16738	Meat							48.39	35.99	476.7	17.37	82.8	163.9	246.7	230.0	48.25	34.38
	Backbones	3½	0	1,587.6			1,546.0										
16740	Meat							47.54	35.96	487.1	21.18	102.9	257.1	360.0	127.1	26.09	52.78
	Trimmings	27¼	0	12,360.6	25	1	11,368.4										
16742	Meat							16.45	81.93	678.0	5.85	39.7	527.9	567.6	110.4	16.28	77.87
	Tail	¼	0	113.4			1,173.0										
16744	Meat							14.24	82.55	742.3	6.37	47.3	591.5	638.8	103.5	13.93	79.70
	Total	167½	0	75,978.0			75,799.4										

PIG No. 7.—DUROC JERSEY.

	2 American clear backs	39½	0	17,917.2	38	14	17,633.7										
16754	Meat							19.20	76.97	804.5	7.39	59.4	(?) 587.5	646.9	157.6	19.59	73.03
	2 clear bellies	28½	0	12,927.6	29	0	13,154.4										
16756	Meat							21.53	73.56	744.7		57.6	(?) 788.9				
	2 short-cut hams	23½	0	10,659.6	23	13	10,801.4										
16758	Meat							44.26	43.38	578.3	14.73	85.2	245.2	330.4	247.9	42.87	42.40
	2 New York shoulders	19½	0	8,845.2	19	12	8,958.6										
16760	Meat							44.60	43.56	641.5	14.90	95.6	265.6	361.2	280.3	43.68	41.42
	4 feet (1 hoof)	c 2½	0	b 1,134.0			b 1,400.0										
16762	Meat							53.76	26.43	215.2	21.46	46.2	51.4	97.6	117.6	54.66	23.88
	Spareribs	3½	0	1,587.6			1,504.0										
16764	Meat							52.86	27.52	484.7	21.77	105.5	127.1	232.6	252.1	52.01	26.22
16766	Tenderloins	¾	0	340.2			333.3	65.70	11.57	194.15	20.76	40.3	14.2	54.5	139.65	71.93	7.31
	Neck bones	2	0	907.2			906.5										
16767	Meat							50.02	33.30	224.5	20.09	45.1	65.0	110.1	114.4	50.96	28.95
	Backbones	3	0	1,360.8			1,482.0										
16769	Meat							51.75	30.71	231.2	22.45	51.9	59.1	110.0	120.2	51.99	25.56
	Trimmings	24¾	0	11,226.6	23	11	10,744.7										
16771	Meat							21.30	78.41	868.3	7.35	63.8	630.3	694.1	174.2	20.06	72.59
	Tail	¼	0	113.4			759.0										
16773	Meat							13.22	85.04	474.5	5.94	28.2	382.6	410.8	63.7	13.43	80.63
	Total	147¾	0	b 67,019.4			b 67,677.6										

[a] Missing hoof, 8.9 grams.

[b] Corrected for missing hoofs.

[c] Missing hoofs, 45.5 grams.

TABLE NO. 1.—*Weights of whole cuts and data relating to the preparation of air-dry samples*—Continued.

PIG NO. 8.—YORKSHIRE.

Serial No. of air-dry meats.	Names of cuts.	Weights of whole cuts.						Direct determinations on original material.		Preparation of air-dry samples.							
		Chicago.			Washington.			Water.	Fat.	Weight of fresh sample.	Air-dry sample of original material.	Weight of air-dry sample after extraction.	Weight of fat.	Air-dry sample plus fat.	Weight of water removed.	Removed in preparation of sample.	
																Water.	Fat.
		Lbs.	*Oz.*	*Grams.*	*Lbs.*	*Oz.*	*Grams.*	*Per ct.*	*Per ct.*	*Grams.*	*Per ct.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Per ct.*	*Per ct.*
	2 American clear backs	44	0	19,958.4	43	13	19,873.4										
16783	Meat							28.00	63.88	884.2	9.67	85.45	551.2	636.7	247.5	27.99	62.34
	2 clear bellies	22½	0	10,206.0	23	1	10,461.2										
16785	Meat							33.58	36.97	926.8	11.09	102.8	517.5	620.3	306.5	33.08	55.83
	2 short-cut hams	27	0	12,247.2	27	4	12,360.6										
16787	Meat							54.80	28.64	704.7	21.97	154.8	141.1	295.9	408.8	58.02	20.01
	2 New York shoulders	24½	0	11,113.2	25	5	12,502.4										
16789	Meat							49.57	36.09	646.8		133.8	Lost.				
	4 feet (8 hoofs)	4½	0	2,041.2			2,246.0										
16791	Meat							57.47	30.86	284.7		62.0	Lost.				
	Spareribs	5	0	2,268.0			2,340.0										
16793	Meat							51.55	30.18	561.4	22.26	125.0	150.5	275.5	285.9	50.93	26.81
16795	Tenderloins	1	0	453.6			632.5	65.24	13.35	461.3	25.23	116.4	43.0	159.4	301.9	65.45	9.32
	Neck bones	2	0	907.2			1,192.3										
16796	Meat							53.25	29.29	439.8	19.92	87.6	115.3	202.9	236.9	53.87	26.21
	Backbones	4	0	1,814.4			1,998.0										
16798	Meat							49.84	30.58	727.8	23.55	171.4	197.4	368.8	359.0	49.33	27.12
	Trimmings	24¾	0	11,226.6	18	10	8,448.3										
16800	Meat							26.07	66.22	756.1	10.25	77.5	485.4	562.9	193.2	25.55	64.20
	Tail	¼	0	113.4			651.0										
16802	Meat							20.38	72.73	315.2	9.96	31.4	227.0	258.4	56.8	18.02	72.02
	Total	159½	0	72,349.2			72,705.7										

TABLE NO. 2.—*Weights of parts from each cut and data relating to the preparation of air-dry samples.*

PIG NO. 1.—BERKSHIRE.

Serial No.	Names of parts and cuts.	Weights of parts.		Of entire pig.	Preparation of sample.										
		From each cut.	Total.		Weight of fresh sample.	Weight of air-dry sample.	Water removed.	Water removed.	Weight of air-dried material taken for extraction.	Weight of extracted sample, air-dry.	Fat removed.	Water removed during extraction.	Weight of original sample equivalent to weight of air-dry sample taken for extraction	Removed from original sample.	
														Water.	Fat.
		Grams.	*Grams.*	*Per cent.*	*Grams.*	*Grams.*	*Grams.*	*Per cent.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Per ct.*	*Per ct.*
	Meat (fat and lean):														
	Backs	14,767.9													
	Bellies	8,230.6													
	Hams	9,407.9													
	Shoulders	8,448.2													
	Feet	325.3													
	Spareribs	1,683.8													
	Tenderloins	470.8													
	Neck bones	493.2													
	Backbones	704.0													
	Trimmings	7,021.5													
	Tail	291.7													
			51,844.9	88.19											
	Bones:														
	Backs	191.1													
	Bellies	81.4													
	Hams	879.6													
	Shoulders	693.8													
	Feet	802.6													
	Spareribs	528.2													
	Neck bones	336.1													
	Backbones	833.5													
	Trimmings	71.0													
	Tail	27.1													
	Total		4,444.4												
16691	Marrow	69.7	69.7	0.12	69.7		9.8			4.44% 3.1	56.8			14.06	81.50
16690	Total bones less marrow.		4,374.7	7.44	1,798.0	1,178.0	620.0	34.48	500.0	52.67% 401.8	87.0	11.2	763.1	35.93	11.40

TABLE NO. 2.—*Weights of parts from each cut and data relating to the preparation of air-dry samples*—Continued.

PIG NO. 2.—TAMWORTH.

Serial No.	Names of parts and cuts	Weights of parts.		Of entire pig.	Preparation of sample.										
		From each cut.	Total.		Weight of fresh sample.	Weight of air-dry sample.	Water removed.	Water removed.	Weight of air-dried material taken for extraction.	Weight of extracted sample, air-dry.	Fat removed.	Water removed during extraction.	Weight of original sample equivalent to weight of air-dry sample taken for extraction.	Removed from original sample.	
														Water.	Fat.
		Grams.	*Grams.*	*Per cent.*	*Grams.*	*Grams.*	*Grams.*	*Per cent.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Per ct.*	*Per ct.*
	Meat (fat and lean):														
	Backs	17,201.7													
	Bellies	8,281.8													
	Hams	10,110.2													
	Shoulders	8,256.6													
	Feet	452.3													
	Spareribs	1,575.7													
	Tenderloins	528.2													
	Neck bones	459.5													
	Backbones	860.2													
	Trimmings	6,979.4													
	Tail	599.5													
			55.305.1	86.50											
	Bones:														
	Backs	222.1													
	Bellies	116.8													
	Hams	1,111.0													
	Shoulders	872.8													
	Feet	1,056.7													
	Spareribs	557.0													
	Neck bones	411.5													
	Backbones	934.0													
	Trimmings	46.0													
	Tail	37.8													
	Total		5,365.7												
16720	Marrow	133.9	133.9	0.21	133.9					2.39% 3.2	113.1	17.6		13.14	84.47
16719	Total bones less marrow.	5,056.0	5,231.8	8.18	2,582.0	1,699.0	883.0	34.20	500.0	50.71% 385.4	112.6	2.0	759.9	34.46	14.83

PIG No. 8.—CHESTER WHITE.

	Meat (fat and lean):													
	Backs	15,217.9												
	Bellies	8,966.6												
	Hams	7,765.3												
	Shoulders	8,468.4												
	Feet	269.1												
	Spareribs	1,012.8												
	Tenderloins	453.6												
	Neck bones	427.1												
	Backbones	584.5												
	Trimmings	6,398.9												
	Tail	633.9												
			50,198.1	87.94										
	Bones:													
	Backs	135.8												
	Bellies	74.9												
	Hams	751.0												
	Shoulders	661.1												
	Feet	679.0												
	Spareribs	396.2												
	Neck bones	249.7												
	Backbones	556.0												
	Trimmings	49.1												
	Tail	36.0												
	Total		3,588.8											
16631	Marrow	43.6	43.6	0.08	43.6					(4.64%) 2.02	34.82	6.76		15.50	79.86
16630	Total bones less marrow.		3,545.2	6.21	1,740.4	1,081.4	659.0	37.86	500.0	(45.56%) 366.6	136.5	—3.1	804.63	37.47	16.97

TABLE NO. 2.—*Weight of parts from each cut and data relating to the preparation of air-dry samples*—Continued.

PIG No. 4.—POLAND CHINA.

Serial No.	Names of parts and cuts.	Weights of parts.		Of entire pig.	Preparation of sample.									
		From each cut.	Total.		Weight of fresh sample.	Weight of air-dry sample.	Water removed.	Water removed.	Weight of air-dried material taken for extraction.	Weight of extracted sample air-dry.	Fat removed.	Water removed during extraction.	Weight of original sample equivalent to weight of air-dry sample taken for extraction.	Removed from original sample.	
														Water.	Fat.
		Grams.	*Grams.*	*Per cent.*	*Grams.*	*Grams.*	*Grams.*	*Per cent.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Per ct.*	*Per ct.*
	Meat (fat and lean):														
	Backs	16,830.2													
	Bellies	10,151.8													
	Hams	10,636.0													
	Shoulders	9,735.5													
	Feet	466.6													
	Spareribs	1,522.4													
	Tenderloins	419.8													
	Neck bones	537.9													
	Backbones	636.6													
	Trimmings	8,574.3													
	Tail	671.6													
			60,182.7	90.67											
	Bones:														
	Backs	114.3													
	Bellies	56.7													
	Hams	731.1													
	Shoulders	602.1													
	Feet	673.5													
	Spareribs	447.1													
	Neck bones	266.5													
	Backbones	639.0													
	Trimmings	32.7													
	Tail	28.0													
	Total		3,591.0												
16665	Marrow	72.0	72.0	0.11	72.0					(5.28%) 3.8	56.4	11.8		16.89	78.33
16663	Total bones less marrow.		3,519.0	5.30	1,729.7	1,042.2	687.5	39.75	500.0	(50.37%) 418.0	78.0	4.0	829.88	40.23	9.40

PIG No. 5.—DUROC JERSEY.

	Meat (fat and lean):														
	Backs	16,709.2													
	Bellies	10,189.1													
	Hams	8,396.1													
	Shoulders	7,971.0													
	Feet	200.1													
	Spareribs	1,195.4													
	Tenderloins	348.5													
	Neck bones	488.5													
	Backbones	702.3													
	Trimmings	8,155.7													
	Tail	596.6													
			54,952.5	88.03											
	Bones:														
	Backs	145.0													
	Bellies	55.0													
	Hams	698.0													
	Shoulders	597.0													
	Feet	774.0													
	Spareribs	416.6													
	Neck bones	283.2													
	Backbones	722.3													
	Trimmings	43.4													
	Tail	30.0													
	Total		3,764.5												
16601	Marrow	67.2	67.2	0.11	67.2					(6.25%) 4.2	54.4	8.6		12.80	80.95
16600	Total bones less marrow.		3,697.3	5.92	1,655.0	1,084.8	570.2	34.45	500.0	(53.64%) 409.2	88.3	2.5	762.78	34.78	11.58

TABLE NO. 2.—*Weights of parts from each cut and data relating to the preparation of air-dry samples*—Continued.

PIG NO. 6.—DUROC JERSEY.

Serial No.	Names of parts and cuts.	Weights of parts.		Of entire pig.	Preparation of sample.										
		From each cut.	Total.		Weight of fresh sample.	Weight of air-dry sample.	Water removed.	Water removed.	Weight of air-dried material taken for extraction.	Weight of extracted sample, air-dry.	Fat removed.	Water removed during extraction.	Weight of original sample equivalent to weight of air-dry sample taken for extraction.	Removed from original sample.	
														Water.	Fat.
		Grams.	*Grams.*	*Per cent.*	*Grams.*	*Grams.*	*Grams.*	*Per cent.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Per ct.*	*Per ct.*
	Meat (fat and lean):														
	Backs	19,194.9													
	Bellies	14,101.6													
	Hams	11,120.6													
	Shoulders	9,171.7													
	Feet	493.7													
	Spareribs	1,214.3													
	Tenderloins	421.3													
	Neck bones	635.6													
	Backbones	809.7													
	Trimmings	10,679.6													
	Tail	1,070.7													
			68,913.7	90.93											
	Bones:														
	Backs	169.8													
	Bellies	68.5													
	Hams	720.9													
	Shoulders	585.0													
	Feet	671.0													
	Spareribs	397.9													
	Neck bones	242.3													
	Backbones	696.0													
	Trimmings	65.3													
	Tail	27.0													
	Total		3,643.7												
16751	Marrow	79.0	79.0	0.10											
16748	Total bones less marrow.		3,564.7	4.70	1,793.5	1,227.5	566.0	31.56	500.0	(51.74%) 378.0	127.7	—5.7	730.57	30.78	17.48

PIG No. 7.—DUROC JERSEY.

	Meat (fat and lean):														
	Backs	16,807.7													
	Bellies	12,404.8													
	Hams	9,746.2													
	Shoulders	8,043.4													
	Feet	290.8													
	Spareribs	1,114.1													
	Tenderloins	333.3													
	Neck bones	611.4													
	Backbones	785.8													
	Trimmings	10,029.2													
	Tail	672.8													
			60,839.5	89.90											
	Bones:														
	Backs	105.0													
	Bellies	58.5													
	Hams	684.7													
	Shoulders	587.0													
	Feet	665.2													
	Spareribs	389.9													
	Neck bones	281.1													
	Backbones	654.0													
	Trimmings	53.0													
	Tail	23.7													
	Total		3,502.1												
16776	Marrow	76.1	76.1	0.11	76.1										
16775	Total bones less marrow.		3,426.0	5.07	1,859.3	1,231.8	627.5	33.75	500.0	(53.50%) 403.8	97.2	—1.0	754.72	33.62	12.88

TABLE NO. 2.—*Weight of parts from each cut and data relating to the preparation of air-dry samples*—Continued.

PIG NO. 8.—YORKSHIRE.

Serial No.	Names of parts and cuts.	Weights of parts.		Of entire pig.	Preparation of sample.										
		From each cut.	Total.		Weight of fresh sample.	Weight of air-dry sample.	Water removed.	Water removed.	Weight of air dried material taken for extraction.	Weight of extracted sample air-dry.	Fat removed.	Water removed during extraction.	Weight of original sample equivalent to weight of air-dry sample taken for extraction.	Removed from original sample.	
														Water.	Fat.
		Grams.	*Grams.*	*Per cent.*	*Grams.*	*Grams.*	*Grams.*	*Per cent.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Per ct.*	*Per ct.*
	Meat (fat and lean):														
	Backs	18,458.1													
	Bellies	9,562.2													
	Hams	10,682.4													
	Shoulders	11,124.8													
	Feet	673.3													
	Spareribs	1,774.0													
	Tenderloins	632.5													
	Neck bones	770.9													
	Backbones	1,100.0													
	Trimmings	7,743.6													
	Tail	565.5													
			63,087.3	86.79											
	Bones:														
	Backs	246.3													
	Bellies	61.8													
	Hams	1,220.0													
	Shoulders	946.2													
	Feet	1,089.0													
	Spareribs	566.0													
	Neck bones	408.0													
	Backbones	898.0													
	Trimmings	81.2													
	Tail	23.0													
	Total		5,486.9												
16805	Marrow	92.9	92.9	0.13	92.9					(4.41%) 4.1	75.78	13.02		14.02	81.57
16804	Total bones less marrow.		5,394.0	7.41	2,470.9	1,615.7	855.2	34.61	500.0	(50.51%) 886.2	105.1	8.7	764.64	35.75	13.74

TABLE NO. 3.—*Weight of parts from each cut and data relating to the preparation of air-dry samples.*

PIG NO. 1.—BERKSHIRE.

Serial No.	Names of parts and cuts.	Weight of parts.		Of entire pig.	Direct determinations on original material.		Preparation of samples.							
		From each cut.	Total.		Water.	Fat.	Weight of fresh sample.	Weight of air-dry sample after extraction.	Weight of fat.	Air-dry sample + fat.	Weight of water removed.	Air-dry sample in the original material.	Removed in preparation of sample.	
													Water.	Fat.
		Grams.	*Grams.*	*Per cent.*	*Per ct.*	*Per ct.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Per ct.*	*Per ct.*	*Per ct.*
16688	Skin				57.66	16.84	183.6	67.8	29.2	97.0	86.6	36.93	47.17	15.90
	Backs	633.5												
	Bellies	419.8												
	Hams	287.1												
	Shoulders	253.5												
	Feet	174.1												
	Trimmings	420.3												
	Tail	44.2												
			2,232.5	3.80										
16693	Spinal cord						55.7	4.9	14.5	19.4	36.3	8.80	65.17	26.03
	Neck bones	13.2												
	Backbones	42.5												
			55.7	0.09										
16695	Tendons						191.3	61.1	24.7	85.8	105.5	31.93	55.16	12.91
	Feet	159.5	159.5	0.27										
17177	Hoofs (7):													
	Feet (corrected)	52.6	52.6	0.09			52.6	*a* 33.37			19.23	63.44	36.56	

TABLE NO. 3.—*Weight of parts from each cut and data relating to the preparation of air-dry samples*—Continued.

PIG NO. 2.—TAMWORTH.

Serial No.	Names of parts and cuts.	Weight of parts.		Of entire pig.	Direct determinations on original material.		Preparation of samples.							
		From each cut.	Total.		Water.	Fat.	Weight of fresh sample.	Weight of air-dry sample after extraction.	Weight of fat.	Air-dry sample + fat.	Weight of water removed.	Air-dry sample in the original material.	Removed in preparation of sample.	
													Water.	Fat.
		Grams.	*Grams.*	*Per cent.*	*Per ct.*	*Per ct.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Per ct.*	*Per ct.*	*Per ct.*
16717	Skin				48.74	20.02	240.4	82.4	30.7	113.1	127.3	34.28	52.95	12.77
	Backs	947.0												
	Bellies	475.0												
	Hams	459.0												
	Shoulders	282.8												
	Feet	261.9												
	Trimmings	515.7												
	Tail	70.2												
			3,011.6	4.71										
16722	Spinal cord						60.8	5.4	27.5	32.9	27.9	8.88	45.88	45.24
	Neck bones	15.0												
	Backbones	45.8												
			60.8	0.09										
16724	Tendons						176.7	59.5	13.8	73.3	103.4	33.67	58.52	7.81
	Feet	138.7	138.7	0.21										
17178	Hoofs (6):													
	Feet (corrected)	64.5	64.5	0.10			64.5	*a* 39.17			25.33	60.73	39.27	

PIG NO. 3.—CHESTER WHITE.

Serial No.	Names of parts and cuts.	From each cut.	Total.	Of entire pig.	Water.	Fat.	Weight of fresh sample.	Weight of air-dry sample after extraction.	Weight of fat.	Air-dry sample + fat.	Weight of water removed.	Air-dry sample in the original material.	Removed: Water.	Removed: Fat.
16633	Skin				40.78	31.17	431.5		*b* 78.1					*c* 18.10
	Backs	862.5												
	Bellies	484.1												
	Hams	541.5												
	Shoulders	311.0												
	Feet	184.6												
	Trimmings	696.2												
	Tail	70.3												
			3,150.2	5.52										

16635	Spinal cord: *d*													
	Neck bones	6.9												
	Backbones	32.1												
			39.0	0.07										
16637	Tendons						75.1	25.7	7.6	33.3	41.8	34.22	55.66	10.12
	Feet	67.2	67.2	0.12										
17179	Hoofs (4):													
	Feet (corrected)	37.0	37.0	0.06			37.0	*a* 24.19			12.81	65.38	34.62	

PIG No. 4.—POLAND CHINA.

16659	Skin				38.10	24.21	311.8	104.0	68.8	172.8	138.5	33.41	44.49	22.10
	Backs	632.5												
	Bellies	507.6												
	Hams	369.8												
	Shoulders	293.5												
	Feet	78.0												
	Trimmings	465.0												
	Tail	60.4												
			2,406.8	3.63										
16661	Spinal cord						50.6	6.2	21.1	27.3	23.3	12.25	46.05	41.70
	Neck bones	11.2												
	Backbones	39.9												
			51.1	0.08										
16664	Tendons						121.5	42.8	13.9	56.7	64.8	35.22	53.34	11.44
	Feet	96.0	96.0	0.14										
17180	Hoofs (8):													
	Feet	44.9	44.9	0.07			44.9	*a* 25.39			19.51	56.55	43.45	

a Not extracted.

b Ether extract lost (poured).

c Poured.

d Sample lost.

TABLE NO. 3.—*Weight of parts from each cut and data relating to the preparation of air-dry samples*—Continued.

PIG NO. 5.—DUROC JERSEY.

Serial No.	Names of parts and cuts.	Weight of parts.		Of entire pig.	Direct determinations on original material.		Preparation of samples.						Removed in preparation of sample.	
		From each cut.	Total.		Water.	Fat.	Weight of fresh sample.	Weight of air dry sample after extraction.	Weight of fat.	Air-dry sample + fat.	Weight of water removed.	Air-dry sample in the original material.	Water.	Fat.
		Grams.	*Grams.*	*Per cent.*	*Per ct.*	*Per ct.*	*Grams.*	*Grams.*	*Grams.* (a)	*Grams.*	*Grams.*	*Grams.*	*Per ct.*	*Per ct.*
16603	Skin				35.49	38.16								
	Backs	1,063.0												
	Bellies	699.0												
	Hams	431.5												
	Shoulders	419.0												
	Feet	190.1												
	Trimmings	731.2												
	Tail	56.4												
			3,590.2	5.75										
16605	Spinal cord						23.8	4.3	5.62	9.92	13.88	18.07	58.32	23.61
	Neck bones	12.3												
	Backbones	13.4												
			25.7	0.04										
16607	Tendons: *b*													
	Feet	59.6	59.6	0.10										
17181	Hoofs (7):													
	Feet (corrected)	31.6	31.6	0.05			31.6	*c* 22.13			9.47	70.03	29.97	
	PIG NO. 6.—DUROC JERSEY.													
16746	Skin				45.20	20.59	420.2	152.5	*d* 28.1					
	Backs	820.5												
	Bellies	657.0												
	Hams	349.0												
	Shoulders	279.2												
	Feet	230.8												
	Trimmings	623.5												
	Tail	75.3												
			3,035.3	4.00										
16749	Spinal cord: *b*													
	Neck bones	14.7												
	Backbones	40.3												
			55.0	0.07										
16753	Tendons						92.5	31.92	8.56	40.48	52.02	34.51	56.24	9.25
	Feet	92.5	92.5	0.12										
17182	Hoofs (8):													
	Feet	59.2	59.2	0.08			59.2	*c* 34.83			24.37	58.83	41.17	

PIG No. 7.—DUROC JERSEY.

16778	Skin				49.26	16.39	447.0	175.2	63.8	239.0	208.0	39.18	46.55	14.27
	Backs	721.0												
	Bellies	691.1												
	Hams	370.5												
	Shoulders	328.2												
	Feet	314.0												
	Trimmings	662.5												
	Tail	62.5												
			3,149.8	4.65										
16780	Spinal cord						56.2	7.17	37.78	44.95	11.25	12.76	20.02	67.22
	Neck bones	14.0												
	Backbones	42.2												
			56.2	0.08										
16782	Tendons						78.0	24.91	10.82	35.73	42.27	31.94	54.19	13.87
	Feet	78.0	78.0	0.11										
17183	Hoofs (1):													
	Feet (corrected)	52.0	52.0	0.08			52.0	c 31.23			20.77	60.06	39.94	

PIG No. 8.—YORKSHIRE.

16807	Skin				52.50	11.71	(b)							
	Backs	1,169.0												
	Bellies	837.2												
	Hams	458.2												
	Shoulders	431.4												
	Feet	275.2												
	Trimmings	623.5												
	Tail	62.5												
			3,857.0	5.30										
16809	Spinal cord: b													
	Neck bones	13.4												
	Backbones	52.6												
			66.0	0.09										
16811	Tendons: b													
	Feet	133.5	133.5	0.18										
17184	Hoofs (8):													
	Feet	75.0	75.0	0.10			75.0	c 38.27			36.73	51.03	48.97	

a Ether extract lost. b Sample lost. c Not extracted. d Ether extract lost (poured).

TABLE No. 4.—*Ana*

PIG No. 1.—BERKSHIRE.

Serial No.	Names of cuts.	Air-dry sample: Per cent of original material.	Per cent air-dry material.							
					Nitrogen.					
			Water.	Fat.	Total.	Of proteids insoluble in hot water.	Precipitated by bromin.	Of flesh bases.	Lecithin.	Ash.
16667	2 American backs	13.16	8.14	20.55	11.32	8.51	0.62	2.19	1.16	3.89
16669	2 clear bellies	14.33	3.14	21.59	11.15	7.78	0.65	2.72	0.99	3.85
16671	2 short-cut hams	22.95	4.14	15.43	11.85	9.77	0.48	1.60	1.10	4.18
17165	(Fat extracted with ether)	16.58	......	......	0.22	......	......	......	2.43	......
16673	2 New York shoulders	17.65	2.31	2.10	13.76	10.22	0.73	2.81	0.85	5.03
16675	4 feet	25.10	6.46	6.32	13.73	7.75	3.00	2.98	0.75	3.28
17174	(Fat extracted with ether)	15.20	......	......	0.13	......	......	......	2.68	......
16677	Spareribs	20.81	3.66	8.23	13.03	10.31	0.89	1.83	1.68	4.80
16679	Tenderloins	27.11	5.14	9.47	12.50	10.95	0.28	1.27	1.82	4.30
16680	Neck bones	20.02	7.23	10.93	12.25	9.97	0.59	1.69	1.33	4.02
17159	(Fat extracted with ether)	18.69	......	......	0.21	......	......	......	2.17	......
16682	Backbones	22.24	3.36	6.88	13.03	10.36	0.62	2.05	1.20	5.59
16684	Trimmings	9.72	3.69	8.34	13.09	8.54	1.11	3.44	1.16	4.23
16686	Tail	8.73	4.30	6.97	13.45	10.56	0.98	1.91	1.98	4.41
	PIG No. 2.—TAMWORTH.									
16696	2 American clear backs	10.48	3.46	12.22	12.61	8.74	1.08	2.79	1.23	4.06
16698	2 American clear bellies	12.12	4.27	14.91	12.44	9.19	0.86	2.39	1.23	3.90
16700	2 short-cut hams	19.99	5.38	8.79	12.92	10.41	0.50	2.01	1.11	4.22
16702	2 New York shoulders	20.36	3.54	19.93	11.44	8.86	0.70	1.58	1.20	3.86
16704	4 feet	23.85	6.24	4.59	14.04	7.81	2.25	3.98	1.57	3.60
17149	(Fat extracted with ether)	15.50	......	......	0.16	......	......	......	0.87	......
16706	Spareribs	19.67	5.49	8.51	12.75	9.38	1.06	2.31	1.27	4.75
16708	Tenderloins	24.12	4.74	8.38	12.92	11.37	0.37	1.18	1.46	4.40
17131	(Fat extracted with ether)	11.49	......	......	0.22	......	......	......	2.98	......
16709	Neck bones	20.95	5.44	6.49	13.36	10.24	0.98	2.14	1.24	4.88
17164	(Fat extracted with ether)	19.43	......	......	0.14	......	......	......	2.91	......

lytical data for meats.

PIG No. 1.—BERKSHIRE.

Per cent original material.																
Water.			Fat.				Nitrogen.				Nitrogenous substances.					
In preparing sample.	In air-dry material.	Total.	In preparing sample.	In air-dry material.	Total.	Lecithin.	Total.	Of proteids insoluble in hot water.	Precipitated by bromin.	Of flesh bases.	Proteids insoluble in hot water.	Gelatinoids.	Flesh bases.	Total.	Ash.	Total.[1]
31.86	0.41	32.27	54.98	2.71	57.69	0.15	1.49	1.12	0.08	0.29	7.00	0.50	0.91	8.41	0.51	98.46 98.88
36.82	0.45	37.27	48.84	3.09	51.93	0.14	1.60	1.12	0.09	0.39	7.00	0.56	1.22	8.78	0.55	98.11 98.53
60.47	0.95	61.42	16.58	3.54	20.12	0.25	2.72	2.24	0.11	0.37	14.00	0.69	1.15	15.84	0.96	99.28 98.34
......	......	......	......	......	......	0.40	0.04	......	......	......	......	......	......	......	......	......
						0.65										
53.64	0.41	54.04	28.71	0.37	29.08	0.15	2.43	1.80	0.13	0.50	11.25	0.81	1.56	13.62	0.89	98.49 97.63
59.66	1.62	61.28	15.24	1.59	16.83	0.20	3.45	1.95	0.75	0.75	12.19	4.69	2.34	19.22	0.82	96.86 98.15
......	......	......	......	......	......	0.41	0.02	......	......	......	......	......	......	......	......	......
						0.61										
51.78	0.76	52.54	27.39	1.71	29.10	0.35	2.71	2.15	0.18	0.38	13.44	1.13	1.19	15.76	1.00	97.14 98.40
66.67	1.39	68.06	6.21	2.57	8.78	0.49	3.39	2.97	0.08	0.34	18.56	0.50	1.06	20.12	1.17	97.57 98.13
54.25	1.45	55.70	25.73	2.19	27.92	0.27	2.45	1.99	0.12	0.34	12.44	0.75	1.06	14.25	0.81	97.60 98.68
......	......	......	......	......	......	0.41	0.04	......	......	......	......	......	......	......	......	......
						0.68										
52.08	0.75	52.83	25.69	1.53	27.22	0.26	2.90	2.30	0.14	0.46	14.38	0.87	1.44	16.69	1.24	96.98 97.98
29.11	0.36	29.47	61.17	0.81	61.98	0.11	1.27	0.83	0.11	0.33	5.19	0.69	1.03	6.91	0.41	99.00 98.77
23.64	0.38	24.02	67.62	0.61	68.23	0.17	1.17	0.92	0.09	0.16	5.75	0.56	0.50	6.81	0.39	100.44 99.45

PIG No. 2.—TAMWORTH.

41.48	0.36	41.84	48.04	1.28	49.32	0.13	1.32	0.92	0.11	0.29	5.75	0.69	0.91	7.35	0.43	98.67 98.94
33.17	0.52	33.69	54.71	1.81	56.52	0.15	1.51	1.12	0.10	0.29	7.00	0.63	0.91	8.54	0.47	100.81 99.22
......	1.08	......	......	1.76	......	0.22	2.58	2.08	0.10	0.40	13.00	0.63	1.25	14.88	0.84	98.10 ......
......	0.72	......	......	4.06	......	0.24	2.33	1.80	0.14	0.38	11.25	0.87	1.19	13.31	0.79	79.15 ......
58.39	1.49	59.88	17.76	1.09	18.85	0.37	3.35	1.86	0.54	0.95	11.63	3.38	2.96	17.97	0.86	98.72 97.56
......	......	......	......	......	......	0.14	0.03	......	......	......	......	......	......	......	......	......
						0.51										
48.12	1.08	49.20	32.21	1.67	33.88	0.25	2.51	1.85	0.21	0.45	11.56	1.31	1.40	14.27	0.93	84.57 98.28
64.38	1.14	65.52	11.49	2.02	13.51	0.35	3.12	2.74	0.09	0.29	17.13	0.56	0.91	18.60	1.06	97.27 98.69
......	......	......	......	......	......	0.56	0.03	......	......	......	......	......	......	......	......	......
						0.91										
54.38	1.14	55.52	24.67	1.36	26.03	0.26	2.80	2.14	0.21	0.45	13.38	1.31	1.40	16.09	1.02	98.46 98.66
......	......	......	......	......	......	0.57	0.03	......	......	......	......	......	......	......	......	......
						0.83										

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[1] In this column the totals obtained by both the direct and the indirect determination of water and fat are given. The upper number in each case was obtained by use of the results of direct determinations of these constituents; for the lower number in each case the results obtained during the preparation of the sample, and in the analysis of the dry-air sample, were used. Lecithin is not included in the totals given in this table.

TABLE NO. 4.—Ana

PIG No. 2.—TAMWORTH—Continued.

Serial No.	Names of cuts.	Air-dry sample: Per cent of original material.	Per cent air-dry material.							
			Water.	Fat.	Nitrogen.				Lecithin.	Ash.
					Total.	Of proteids insoluble in hot water.	Precipitated by bromin.	Of flesh bases.		
16711	Backbones	20.98	6.59	6.36	12.95	10.44	0.68	1.83	1.19	5.25
16713	Trimmings	10.53	4.83	14.61	12.41	8.08	1.24	3.09	0.98	4.05
16715	Tail	9.53	4.83	20.15	10.90	7.13	1.15	2.62	1.09	3.15
	PIG No. 3.—CHESTER WHITE.									
16609	2 American clear backs	10.09	2.18	22.71	10.17	7.12	0.73	2.32	1.23	3.47
16611	2 American clear bellies	9.81	2.23	8.75	13.20	8.82	1.01	3.37	0.85	4.31
16613	2 short-cut hams	24.30	2.65	32.10	10.34	7.34	0.42	2.58	1.42	3.28
16615	2 New York shoulders	17.75	9.86	12.01	11.69	8.50	0.78	2.41	1.57	4.01
16617	4 feet	20.71	4.00	3.32	14.21	7.64	4.92	1.65	0.93	4.08
16619	Spareribs	26.69	2.95	26.47	10.67	8.17	0.52	1.98	1.04	3.45
16621	Tenderloins	25.88	3.89	16.65	11.88	10.32	0.27	1.29	1.55	4.09
16622	Neck bones	19.30	2.79	9.24	12.89	10.11	0.59	2.19	1.28	4.51
16624	Backbones	19.39	1.88	5.53	13.73	11.05	0.48	2.20	1.19	5.43
16626	Trimmings	7.20	3.87	13.38	11.99	7.16	1.15	3.68	0.99	4.29
16628	Tail	5.65	3.78	9.14	13.29	8.42	1.25	3.62	1.33	4.19
	PIG No. 4.—POLAND CHINA.									
16638	2 American clear backs	9.68	3.21	16.05	12.10	8.50	0.93	2.67	......	3.89
16640	2 American clear bellies	9.43	4.26	5.34	13.23	8.14	1.09	4.00	1.31	4.53
16642	2 short-cut hams	17.00	4.79	6.38	13.23	10.07	0.75	2.41	1.33	4.48
16644	2 New York shoulders	....	15.28	8.00	11.34	8.62	0.68	2.04	1.45	4.07
17152	(Fat extracted with ether) *a*	....	......	......	0.09	......	......	......	2.03	......
16646	4 feet	19.57	7.29	0.59	14.01	9.02	3.42	1.57	0.77	4.64
16648	Spareribs	23.03	4.83	16.65	11.71	6.99	0.42	4.30	1.33	4.11
16650	Tenderloins	26.80	5.88	13.40	11.85	10.53	0.41	0.91	1.45	4.22
16651	Neck bones	19.37	5.96	8.89	12.27	8.46	0.93	2.88	0.89	4.71
17163	(Fat extracted with ether)	20.67	......	......	0.24	......	......	......	1.36	......
16653	Backbones	21.21	3.68	12.07	12.42	9.77	0.62	2.03	1.21	4.95
16655	Trimmings	8.05	3.54	21.29	10.98	7.39	0.87	2.72	0.80	3.91
16657	Tail	6.41	5.48	5.21	13.23	8.61	1.32	3.30	1.19	4.90

a Fat extract lost.

lytical data for meats—Continued.

PIG No. 2.—TAMWORTH—Continued.

Per cent original material.																	
Water.			Fat.				Nitrogen.				Nitrogenous substances.						
In preparing sample.	In air-dry material.	Total.	In preparing sample.	In air-dry material.	Total.	Lecithin.	Total.	Of proteids insoluble in hot water.	Precipitated by bromin.	Of flesh bases.	Proteids insoluble in hot water.	Gelatinoids.	Flesh bases.	Total.	Ash.	Total.
49.68	1.38	51.06	29.34	1.33	30.67	0.25	2.72	2.19	0.14	0.39	13.69	0.87	1.22	15.78	1.10	97.66 98.61
28.34	0.51	28.85	61.13	1.54	62.67	0.10	1.31	0.85	0.13	0.33	5.31	0.81	1.03	7.15	0.43	101.30 99.10
25.31	0.46	25.77	65.16	1.92	67.08	0.10	1.04	0.68	0.11	0.25	4.25	0.69	0.78	5.72	0.30	97.14 98.87

PIG No. 3.—CHESTER WHITE.

71.88	0.22	72.10	18.02	2.29	20.31	0.12	1.03	0.72	0.07	0.24	4.50	0.44	0.75	5.69	0.35	99.92 98.45
30.32	0.22	30.54	59.87	0.86	60.73	0.08	1.30	0.87	0.10	0.33	5.44	0.63	1.03	7.10	0.42	99.15 98.79
52.51	0.64	53.15	23.19	7.80	30.99	0.35	2.51	1.78	0.10	0.63	11.13	0.63	1.97	13.73	0.80	97.93 98.67
......	1.75	......	......	2.13	......	0.28	2.08	1.51	0.14	0.43	9.44	0.87	1.34	11.65	0.71	99.14 ......
......	0.83	......	......	0.69	......	0.19	2.94	1.58	1.02	0.34	9.88	6.38	1.06	17.32	0.84	97.95 ......
52.44	0.79	53.23	20.87	7.06	27.93	0.28	2.85	2.18	0.14	0.53	13.63	0.87	1.65	16.15	0.92	97.67 98.23
64.96	1.01	65.97	9.16	4.31	13.47	0.40	3.07	2.67	0.07	0.33	16.69	0.44	1.03	18.16	1.06	97.94 98.66
52.96	0.54	53.50	27.74	1.78	29.52	0.25	2.49	1.95	0.12	0.42	12.19	0.75	1.31	14.25	0.87	96.35 98.14
50.03	0.36	50.39	30.58	1.07	31.65	0.23	2.66	2.14	0.09	0.43	13.38	0.56	1.34	15.28	1.05	98.18 98.37
22.21	0.28	22.49	70.59	0.96	71.55	0.07	0.87	0.52	0.08	0.27	3.25	0.50	0.84	4.59	0.31	100.11 98.94
......	0.21	......	......	0.52	......	0.08	0.75	0.48	0.07	0.20	3.00	0.44	0.62	4.06	0.24	99.65 ......

PIG No. 4.—POLAND CHINA.

29.22	0.31	29.53	61.10	1.55	62.65	......	1.17	0.82	0.09	0.26	5.13	0.56	0.81	6.50	0.38	99.34 99.06
30.38	0.40	30.78	60.19	0.50	60.69	0.12	1.25	0.77	0.10	0.38	4.81	0.63	1.19	6.63	0.43	98.93 98.53
53.97	0.81	54.78	29.03	1.09	30.12	0.23	2.25	1.71	0.13	0.41	10.69	0.81	1.28	12.78	0.76	98.00 98.44
......	......	51.72	......	......	33.74	0.30	1.65	1.25	0.10	0.30	7.81	0.63	0.94	9.38	0.59	95.43 ......
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
49.23	1.43	50.66	31.20	0.12	31.32	0.15	2.74	1.76	0.67	0.31	11.00	4.19	0.97	16.16	0.91	98.36 99.05
55.53	1.11	56.64	22.44	3.83	26.27	0.31	2.70	1.61	0.10	0.99	10.06	0.63	3.00	13.78	0.95	97.23 97.64
65.85	1.58	67.43	7.36	3.59	10.95	0.39	3.18	2.82	0.11	0.25	17.63	0.69	0.78	19.10	1.13	98.69 98.61
54.08	1.15	55.23	26.55	1.72	28.27	0.17	2.38	1.64	0.18	0.56	10.25	1.13	1.75	13.13	0.91	97.86 97.54
......	......	......	......	......	......	0.28	0.05	......	......	......	......	......	......	......	......	......
						0.45										
48.65	0.78	49.43	30.14	2.56	32.70	0.27	2.63	2.07	0.13	0.43	12.94	0.81	1.34	15.09	1.05	98.38 98.27
22.14	0.29	22.43	69.81	1.71	71.52	0.06	0.88	0.59	0.07	0.22	3.69	0.44	0.69	4.82	0.32	99.29 99.09
16.15	0.35	16.50	77.44	0.33	77.77	0.08	0.85	0.55	0.09	0.21	3.44	0.56	0.66	4.66	0.31	100.36 99.24

TABLE NO. 4.—*Ana*

PIG No. 5.—DUROC JERSEY.

Serial No.	Names of cuts.	Air-dry sample: Per cent of original material.	Per cent air-dry material.							
					Nitrogen.					
			Water.	Fat.	Total.	Of proteids insoluble in hot water.	Precipitated by bromin.	Of flesh bases.	Lecithin.	Ash.
16579	2 American clear backs	9.37	9.69	24.48	10.47	6.76	0.81	2.90	0.82	3.14
16581	2 clear bellies	11.71	3.05	28.08	10.39	6.84	0.80	2.75	0.83	3.57
16583	2 short-cut hams	21.39	3.48	32.93	7.75	6.25	0.73	0.77	0.16	3.34
16585	2 New York shoulders	....	3.98	4.39	13.82	10.11	0.83	2.88	0.84	4.57
16587	4 feet	23.36	5.21	7.88	12.47	6.97	1.52	3.98	......	3.27
16589	Spareribs	22.23	3.21	11.30	12.92	10.14	0.56	2.22	0.53	4.67
16591	Tenderloins	28.54	4.23	18.53	11.69	10.25	0.22	1.22	1.22	3.98
16592	Neck bones	19.46	3.98	7.58	13.20	10.28	0.61	2.31	1.05	4.85
16594	Backbones	25.94	3.44	12.41	12.64	10.08	0.50	2.06	1.52	4.75
16596	Trimmings	6.80	3.98	10.90	12.77	7.66	0.95	4.16	1.14	4.38
16598	Tail	4.70	4.37	13.88	12.19	6.85	1.10	4.24	1.39	4.30

PIG No. 6.—DUROC JERSEY.

16725	2 American clear backs	6.99	6.75	6.71	12.89	8.59	1.07	3.23	0.97	4.17
17133	(Fat extracted with ether)	20.65	......	......	0.13	......	......	......	0.59	......
16727	2 clear bellies	8.30	4.96	16.65	11.79	8.44	1.04	2.31	0.97	2.59
17134	(Fat extracted with ether)	6.17	......	......	0.09	......	......	......	0.51	......
16729	2 short cut hams	27.63	5.49	8.95	12.75	10.05	0.73	1.97	1.28	4.76
16731	2 New York shoulders	12.91	6.58	5.39	13.09	9.30	1.12	2.67	0.92	6.53
16733	4 feet	21.84	7.68	6.72	13.23	7.72	2.11	3.40	0.74	3.44
17142	(Fat extracted with ether)	16.13	......	......	0.12	......	......	......	1.15	......
16735	Spareribs	22.09	5.79	11.79	12.27	9.89	0.80	1.58	1.51	4.96
16737	Tenderloins	26.77	5.67	14.63	11.77	10.35	0.38	1.04	2.09	3.93
16738	Neck bones	17.37	6.02	3.11	13.59	10.77	0.89	1.93	1.61	4.98
16740	Backbones	21.13	4.99	11.98	12.27	9.68	0.82	1.77	1.69	4.35
16742	Trimmings	5.85	3.96	15.48	12.19	8.44	1.07	2.68	1.15	4.18
16744	Tail	6.37	0.12	23.97	10.70	7.53	1.11	2.06	0.92	3.68

lytical data for meats—Continued.

PIG No. 5.—DUROC JERSEY.

Per cent original material.																
Water.			Fat.			Lecithin.	Nitrogen.				Nitrogenous substances.				Ash.	Total.
In preparing sample.	In air-dry material.	Total.	In preparing sample.	In air-dry material.	Total.		Total.	Of proteids insoluble in hot water.	Precipitated by bromin.	Of flesh bases.	Proteids insoluble in hot water.	Gelatinoids.	Flesh bases.	Total.		
......	0.91	......	......	2.29	......	0.08	0.98	0.63	0.08	.27	3.94	0.50	0.84	5.28	0.29	99.57 ......
28.77	0.36	29.13	59.52	3.31	62.83	0.10	1.22	0.81	0.09	0.32	5.06	0.56	1.00	6.62	0.42	100.06 99.00
49.71	0.74	50.45	28.90	7.04	35.94	0.03	1.66	1.34	0.16	0.16	8.38	1.00	0.50	9.88	0.71	95.89 96.98
......	......	44.16	......	......	43.74	0.10	1.67	1.22	0.10	0.35	7.63	0.63	1.09	9.35	0.55	97.80 ......
53.37	1.22	54.59	23.27	1.84	25.11	......	2.91	1.63	0.35	0.93	10.19	2.19	2.90	15.28	0.76	96.39 95.74
53.38	0.71	54.09	24.39	2.51	26.90	0.12	2.87	2.25	0.13	0.49	14.06	0.81	1.53	16.40	1.04	98.41 98.43
65.34	1.21	66.55	6.12	5.29	11.41	0.35	3.34	2.93	0.06	0.35	18.31	0.38	1.09	19.78	1.14	98.86 98.88
51.71	0.77	52.48	28.83	1.48	30.31	0.20	2.57	2.00	0.12	0.45	12.50	0.75	1.40	14.65	0.94	98.63 98.38
47.88	0.89	48.77	26.18	3.22	29.40	0.41	3.28	2.62	0.13	0.53	16.38	0.81	1.65	18.84	1.23	102.50 98.24
19.81	0.27	20.08	73.39	0.74	74.13	0.08	0.87	0.52	0.07	0.28	3.25	0.44	0.87	4.56	0.30	98.89 99.07
11.33	0.21	11.54	83.97	0.65	84.62	0.07	0.57	0.32	0.05	0.20	2.00	0.31	0.62	2.93	0.20	99.46 99.29

PIG No. 6.—DUROC JERSEY.

19.85	0.47	20.32	73.16	0.47	73.63	0.08	0.90	0.60	0.07	0.23	3.75	0.44	0.72	4.91	0.29	100.03 99.15
......	......	......	......	......	......	0.12	0.03	......	......	......	......	......	......	......	......	......
						0.20										
34.11	0.41	34.52	57.59	1.38	58.97	0.08	0.98	0.70	0.09	0.19	4.38	0.56	0.59	5.53	0.22	80.36 99.24
......	......	......	......	......	......	0.04	0.01	......	......	......	......	......	......	......	......	......
						0.12										
35.74	1.52	37.26	36.63	2.47	39.10	0.35	3.52	2.78	0.20	0.54	17.38	1.25	1.69	20.32	1.32	109.26 98.00
38.61	0.85	39.46	48.48	0.70	49.18	0.12	1.69	1.20	0.15	0.34	7.50	0.94	1.06	9.50	0.84	99.62 98.98
50.16	1.68	51.84	28.00	1.47	29.47	0.16	2.89	1.69	0.46	0.74	10.56	2.88	2.31	15.75	0.75	98.14 97.81
......	......	......	......	......	......	0.19	0.02	......	......	......	......	......	......	......	......	......
						0.35										
48.56	1.28	49.84	29.35	2.60	31.95	0.33	2.71	2.18	0.18	0.35	13.63	1.13	1.09	15.85	1.10	98.90 98.74
62.34	1.52	63.86	10.89	3.92	14.81	0.56	3.15	2.77	0.10	0.28	17.31	0.63	0.87	18.81	1.05	97.27 98.53
48.25	1.05	49.30	34.38	0.54	34.92	0.28	2.36	1.87	0.15	0.34	11.69	0.94	1.06	13.69	0.87	98.94 98.78
26.09	1.05	27.14	52.78	2.53	55.31	0.36	2.59	2.05	0.17	0.37	12.81	1.06	1.15	15.02	0.92	99.44 98.39
16.28	0.23	16.51	77.87	0.91	78.78	0.07	0.71	0.49	0.06	0.16	3.06	0.38	0.50	3.94	0.25	102.57 99.47
13.93	0.01	13.94	79.70	1.53	81.23	0.06	0.68	0.48	0.07	0.13	3.00	0.44	0.41	3.85	0.23	100.87 99.25

TABLE NO. 4.—*Ana*

PIG No. 7.—DUROC JERSEY.

Serial No.	Names of cuts.	Air-dry sample: Per cent of original material.	Per cent air-dry material.							
			Water.	Fat.	Nitrogen.				Lecithin.	Ash.
					Total.	Of proteids insoluble in hot water.	Precipitated by bromin.	Of flesh bases.		
16754	2 American clear backs	7.39	8.67	12.48	12.24	8.85	1.16	2.23	1.38	3.92
17155	(Fat extracted with ether)	20.82	......	......	9.05	......	......	......	1.83	......
16756	2 clear bellies	......	5.29	15.79	12.44	9.12	1.18	2.14	1.52	4.29
17156	(Fat extracted with ether)	21.18	......	......	0.06	......	......	......	3.28	......
16758	2 short cut hams	14.73	8.23	2.11	13.11	10.39	0.95	1.77	1.25	4.44
17158	(Fat extracted with ether)	24.80	......	......	0.14	......	......	......	1.09	......
16760	2 New York shoulders	14.90	6.28	8.25	12.58	9.72	1.00	1.86	1.66	6.13
17137	(Fat extracted with ether)	26.49	......	......	0.11	......	......	......	1.38	......
16762	4 feet	21.46	6.13	6.39	13.48	9.24	1.94	2.30	0.84	3.63
17141	(Fat extracted with ether)	18.12	......	......	0.11	......	......	......	1.00	......
16764	Spareribs	21.77	5.46	5.94	13.14	10.72	0.80	1.62	1.67	4.64
17154	(Fat extracted with ether)	20.12	......	......	0.07	......	......	......	2.35	......
16766	Tenderloins	20.76	4.35	9.84	12.58	11.32	0.38	0.88	1.55	4.16
16767	Neck bones	20.09	5.65	9.79	11.74	9.83	0.89	1.02	1.23	4.69
17145	(Fat extracted with ether)	22.72	......	......	0.14	......	......	......	1.30	......
16769	Backbones	22.45	4.89	11.19	12.33	9.87	0.75	1.71	1.26	4.55
17144	(Fat extracted with ether)	20.33	......	......	0.12	......	......	......	0.77	......
16771	Trimmings	7.35	5.88	13.23	11.97	7.30	1.42	3.25	......	3.84
17139	(Fat extracted with ether)	18.10	......	......	0.09	......	......	......	0.63	......
16773	Tail	5.94	5.00	18.81	11.24	7.65	1.30	2.29	3.02	4.49
17138	(Fat extracted with ether)	27.46	......	......	0.09	......	......	......	1.10	......

lytical data for meats—Continued.

PIG No. 7.—DUROC JERSEY.

Per cent original material.																
Water.			Fat.				Nitrogen.				Nitrogenous substances.					
In preparing sample.	In air-dry material.	Total.	In preparing sample.	In air-dry material.	Total.	Lecithin.	Total.	Of proteids insoluble in hot water.	Precipitated by bromin.	Of flesh bases.	Proteids insoluble in hot water.	Gelatinoids.	Flesh bases.	Total.	Ash.	Total.
19.59	0.64	20.23	73.03	0.92	73.95	0.10	0.90	0.65	0.09	0.16	4.06	0.56	0.50	5.12	0.29	101.58 99.59
......	.....	......	......	.....	......	0.38	0.01	......	.....	.....	......	.....	.....	......	.....	......
						0.48										
......	.....	21.53	......	....	73.56	0.32	0.01	0.45	0.06	0.10	2.81	0.38	0.31	3.50	0.21	98.80 ......
......	.....	......	......	.....	......	0.16	0.61	......	.....	.....	......	.....	.....	......	.....	......
						0.48										
42.87	1.21	44.08	42.40	0.31	42.71	0.18	1.93	1.53	0.14	0.26	9.56	0.87	0.81	11.24	0.65	99.53 98.68
......	.....	......	......	.....	......	0.27	0.04	......	.....	.....	......	.....	.....	......	.....	......
						0.45										
43.68	0.94	44.62	41.42	1.23	42.65	0.25	1.88	1.45	0.15	0.28	9.06	0.94	0.87	10.87	0.91	99.94 99.05
......	.....	......	......	.....	......	0.37	0.03	......	.....	.....	......	.....	.....	......	.....	......
						0.62										
54.66	1.32	55.98	23.88	1.37	25.25	0.18	2.89	1.98	0.42	0.49	12.38	2.63	1.53	16.54	0.78	97.51 98.55
......	.....	......	......	.....	......	0.18	0.02	......	.....	.....	......	.....	.....	......	.....	......
						0.36										
52.01	1.19	53.20	26.22	1.29	27.51	0.36	2.86	2.33	0.18	0.35	14.56	1.13	1.09	16.78	1.01	98.17 98.50
......	.....	......	......	.....	......	0.47	0.01	......	.....	.....	......	.....	.....	......	.....	......
						0.83										
71.93	0.90	72.83	7.31	2.04	9.35	0.32	2.61	2.35	0.08	0.18	14.69	0 50	0.56	15.75	0.86	93.88 98.79
50.96	1.14	52.10	28.95	1.97	30.92	0.25	2.36	1.98	0.18	0.20	12.38	1.13	0.62	14.13	0.94	96.01 98.09
......	.....	......	......	.....	......	0.30	0.03	......	.....	.....	......	.....	.....	......	.....	......
						0.55										
51.99	1.10	53.09	25.56	2.51	28.07	0.28	2.77	2.22	0.17	0.38	13.88	1.06	1.19	16.13	1.02	99.61 98.31
......	.....	......	......	.....	......	0.16	0.02	......	.....	.....	......	.....	.....	......	.....	......
						0.44										
20.06	0.43	20.49	72.59	0.97	73.56	......	0.88	0.54	0.10	0.24	3.38	0.63	0.75	4.76	0.28	99.75 99.09
......	.....	......	......	.....	......	0.11	0.016	......	.....	.....	......	.....	.....	......	.....	......
13.43	0.30	13.73	80.63	1.12	81.74	0.18	0.67	0.45	0.08	0.14	2.81	0.50	0.44	3.75	0.27	102.28 99.49
......	.....	......	......	.....	......	0.30	0.025	......	.....	.....	......	.....	.....	......	.....	......
						0.48										

TABLE No. 4.—*Ana*

PIG No. 8.—YORKSHIRE.

Serial No.	Names of cuts.	Air-dry sample: Per cent of original material.	Per cent air-dry material.							
			Water.	Fat.	Nitrogen.				Lecithin.	Ash.
					Total.	Of proteids insoluble in hot water.	Precipitated by bromin.	Of flesh bases.		
16783	2 American clear backs	9.67	5.82	1.95	13.68	9.83	1.74	2.11	1.11	4.28
17160	(Fat extracted with ether)	25.05	......	......	0.12	......	......	......	0.84	......
16785	2 clear bellies	11.09	6.36	3.54	13.43	9.69	1.85	1.91	1.09	4.54
17150	(Fat extracted with ether)	29.54	......	......	0.10	......	......	......	0.45	......
16787	2 short cut hams	21.97	5.12	23.74	10.61	8.38	0.62	1.61	1.29	3.37
17140	(Fat extracted with ether)	18.11	......	......	0.08	......	......	......	0.75	......
16789	2 New York shoulders	....	8.13	3.67	12.92	9.46	0.98	2.48	1.16	4.37
16791	4 feet	....	7.04	6.28	13.48	6.99	2.25	4.24	0.67	3.49
16793	Spareribs	22.26	6.22	11.08	12.47	9.76	0.78	1.93	1.47	4.72
16795	Tenderloins	25.23	4.75	14.86	11.96	10.13	0.51	1.32	1.85	4.14
17143	(Fat extracted with ether)	9.33	......	......	0.14	......	......	......	2.20	......
16796	Neck bones	19.92	6.33	2.50	13.34	10.71	0.79	1.84	1.33	4.98
17135	(Fat extracted with ether)	17.26	......	......	0.15	......	......	......	1.64	......
16798	Backbones	23.55	5.61	10.58	12.19	9.59	0.84	1.76	1.48	4.99
17157	(Fat extracted with ether)	16.68	......	......	0.12	......	......	......	2.60	......
16800	Trimmings	10.25	5.57	15.72	11.63	7.10	1.59	2.94	1.20	3.80
17151	(Fat extracted with ether)	30.31	......	......	0.09	......	......	......	1.05	......
16802	Tail	9.96	4.83	23.55	10.81	7.86	1.68	1.27	1.09	3.83
17147	(Fat extracted with ether)	43.40	......	......	0.08	......	......	......	1.02	......

lytical data for meats—Continued.

PIG No. 8.—YORKSHIRE.

Per cent original material.																
Water.			Fat.				Nitrogen.				Nitrogenous substances.					
In preparing sample.	In air-dry material.	Total.	In preparing sample.	In air dry material.	Total.	Lecithin.	Total.	Of proteids insoluble in hot water.	Precipitated by bromin.	Of flesh bases.	Proteids insoluble in hot water.	Gelatinoids.	Flesh bases.	Total.	Ash.	Total.
27.99	0.56	28.55	62.34	0.19	62.53	0.11	1.32	0.95	0.17	0.20	5.94	1.06	0.62	7.62	0.41	99.91 99.11
......	....	......	......	.....	......	0.21	0.03	......	.....	.....	......	.....	.....	......	.....	......
						0.32										
33.08	0.71	33.79	55.83	0.39	56.22	0.12	1.49	1.08	0.20	0.21	6.75	1.25	0.66	8.66	0.48	79.69 99.15
......	.....	......	......	.....	......	0.13	0.03	......	.....	.....	......	.....	.....	......	.....	......
						0.25										
58.02	1.12	59.14	20.01	5.22	25.23	0.28	2.33	1.84	0.14	0.35	11.50	0.87	1.09	13.46	0.74	97.64 98.57
......	.....	......	......	.....	......	0.14	0.015	......	.....	.....	......	.....	.....	......	.....	......
						0.42										
......	.....	49.57	......	.....	36.09	0.17	1.85	1.36	0.14	0.35	8.50	0.87	1.09	10.46	0.63	96.75 ......
......	.....	57.47	......	.....	30.86	0.08	1.57	0.82	0.26	0.49	5.13	1.63	1.53	8.29	0.41	97.03 ......
50.93	1.38	52.31	26.81	2.47	29.28	0.33	2.78	2.17	0.18	0.43	13.56	1.13	1.34	16.03	1.05	98.81 98.67
65.45	1.20	66.65	9.32	3.75	13.07	0.47	3.02	2.56	0.13	0.33	16.00	0.81	1.03	17.84	1.04	97.47 98.60
......	.....	......	......	.....	......	0.21	.....	......	.....	.....	......	.....	.....	......	.....	......
						0.68										
53.87	1.26	55.13	26.21	0.50	26.71	0.26	2.66	2.13	0.16	0.37	13.31	1.00	1.15	15.46	0.99	98.99 98.29
......	.....	......	......	.....	......	0.28	0.026	......	.....	.....	......	.....	.....	......	.....	......
						0.54										
49.33	1.32	50.65	27.12	2.49	29.61	0.35	2.87	2.26	0.20	0.41	14.13	1.25	1.28	16.66	1.18	98.26 98.10
......	.....	......	......	.....	......	0.43	0.02	......	.....	.....	......	.....	.....	......	.....	......
						0.78										
25.55	0.57	26.12	64.20	1.61	65.81	0.12	1.19	0.73	0.16	0.30	4.56	1.00	0.94	6.50	0.39	99.18 98.82
......	.....	......	......	.....	......	0.32	0.027	......	.....	.....	......	.....	.....	......	.....	......
						0.44										
18.02	0.48	18.50	72.02	2.35	74.37	0.11	1.08	0.78	0.17	0.13	4.88	1.06	0.41	6.35	0.33	99.79 99.55
......	.....	......	......	.....	......	0.44	0.035	......	.....	.....	......	.....	.....	......	.....	......
						0.55										

TABLE No. 5.—*Analytical data for bones,*

PIG No. 1.—BERKSHIRE.

Serial No.	Names of parts.	Air-dry sample, per cent of original material.	Per cent air-dry material.							
			Water.	Fat.	Nitrogen.				Lecithin.	Ash.
					Total.	Of proteids insoluble in hot water.	Precipitated by bromin.	Of flesh bases.		
16690	Bones	52.67	5.72	0.52	6.18	5.32	0.11	0.75	0.84	49.59
16690A	(Fat extracted with ether)	11.40	(0.61)	......	0.29	......	......	......	......	(0.28)
16691	Marrow	4.44	6.68	0.19	8.31	7.08	0.65	0.48	.....	......
17169	(Fat extracted with ether)	17.36	......	......	0.07	......	......	......	2.64	......
16688	Skin	36.93	8.31	3.28	15.02	10.95	2.89	1.18	0.33	1.70
17175	(Fat extracted with ether)	15.90	......	......	0.15	......	......	......	1.85	......
16693	Spinal cord	8.80	6.01	8.28	8.85	7.02	1.26	0.57	.....	......
16695	Tendons	31.93	10.23	1.52	14.10	11.26	2.22	0.62	0.39	3.71
17168	(Fat extracted with ether)	4.81	......	......	0.23	......	......	......	6.65	......
17177	Hoofs	63.44	7.14	1.35	14.63	......	......	......	.....	1.46
	PIG No. 2.—TAMWORTH.									
16719	Bones	50.71	7.10	0.45	6.18	5.45	0.22	0.51	0.07	49.98
16719A	(Fat extracted with ether)	14.83	(0.68)	......	0.34	......	......	......	.....	(0.59)
16720	Marrow	2.39	6.91	0.44	10.56	8.98	0.56	1.02	.....	......
17146	(Fat extracted with ether)	15.53	......	......	0.14	......	......	......	0.31	......
16717	Skin	34.28	7.08	4.04	14.88	7.75	4.21	2.92	0.34	1.89
17132	(Fat extracted with ether)	14.27	......	......	0.16	......	......	......	0.91	......
16722	Spinal cord	8.88	6.41	1.65	9.63	7.30	1.12	1.21	.....	2.54
17166	(Fat extracted with ether)	32.24	......	......	0.44	......	......	......	9.15	......
16724	Tendons	33.67	9.01	0.83	14.86	11.49	2.05	1.32	0.31	3.24
17171	(Fat extracted with ether)	2 55	......	......	0.31	......	......	......	......	......
17178	Hoofs	60.73	6.92	1.01	14.65	......	......	......	.....	1.61
	PIG No. 3.—CHESTER WHITE.									
16630	Bones	45.56	6.46	0.45	6.94	6.04	0.17	0.73	0.13	47.61
16630A	(Fat extracted with ether)	16.97	(0.62)	......	0.34	......	......	......	.....	(0.37)
16631	Marrow	4.64	......	......	7.16	6.46	0.28	0.42	.....	......
16633	Skin	28.05	3.37	3.93	15.02	2.56	3.46	9.00	0.35	1.88
16635	Spinal cord *a*	......	......	......	......	......	......	......	.....	......
16637	Tendons	34.22	13.03	0.84	14.10	11.34	1.53	1.23	0.81	2.48
17179	Hoofs	65.38	7.18	1.07	14.74	......	......	......	.....	1.36
	PIG No. 4.—POLAND CHINA.									
16663	Bones	50.37	4.90	0.93	6.74	5.20	0.56	0.98	1.05	50.13
16663A	(Fat extracted with ether)	9.40	(0.62)	......	0.21	......	......	......	.....	(0.32)
16665	Marrow	5.28	6.66	0.43	8.28	7.12	0.42	0.14	.....	......
16659	Skin	33.41	6.93	3.63	14.86	4.24	5.48	5.14	0.74	1.89
16661	Spinal cord	12.25	6.58	10.15	9.12	7.16	1.40	0.56	.....	4.57
16662	(Fat extracted with ether)	23.32	......	......	0.17	......	......	......	4.70	......
16664	Tendons	35.22	9.48	0.67	14.63	11.24	2.50	0.89	0.29	4.21
17170	(Fat extracted with ether)	4.77	......	......	0.11	......	......	......	.....	......
17180	Hoofs	56.55	7.19	1.06	14.80	......	......	......	.....	1.43

a Lost.

marrow, skin, spinal cord, tendons, and hoofs.

PIG No. 1.—BERKSHIRE.

Per cent original material.																
Water.			Fat.				Nitrogen.				Nitrogenous substances.					
In preparing sample.	In original material.	Total.	In preparing sample.	In original material.	Total.	Lecithin.	Total.	Of proteids insoluble in hot water.	Precipitated by bromin.	Of flesh bases.	Proteids insoluble in hot water.	Gelatinoids.	Flesh bases.	Total.	Ash.	Total.
35.93	3.01	38.94	11.40	0.27	11.67	0.44	3.26	2.80	0.06	0.40	17.50	0.38	1.25	19.13	26.12	95.86
......	(0.07)	......	......	......	......	......	0.03	......	......	......	......	......	......	......	(0.03)	......
14.06	0.30	14.36	81.50	0.01	81.51	......	0.37	0.32	0.03	0.02	2.00	0.19	0.06	2.25	.....	98.12
......	......	......	......	......	......	0.46	0.01	......	......	......	......	......	......	......	......	......
47.17	3.07	50.24	15.90	1.21	17.11	0.12	5.55	4.04	1.07	0.44	25.25	6.69	1.37	33.31	0.63	{108.44 101.29
......	......	......	......	......	......	0.29	0.024	......	......	......	......	......	......	......	......	......
						0.41										
65.17	0.53	65.70	26.03	0.73	26.76	......	0.78	0.62	0.11	0.05	3.88	0.69	0.16	4.73	.....	97.19
55.16	3.27	58.43	12.91	0.49	13.40	0.13	4.50	3.59	0.71	0.20	22.44	4.44	0.62	27.50	1.18	100.51
......	......	......	......	......	......	0.32	0.01	......	......	......	......	......	......	......	......	......
						0.45										
36.56	4.53	41.09	......	......	0.86	......	9.28	......	......	......	......	......	......	58.00	0.93	100.88

PIG No. 2.—TAMWORTH.

34.46	3.60	38.06	14.83	0.23	15.06	0.04	3.18	2.76	0.11	0.26	17.25	0.69	0.81	18.75	25.35	97.22
......	(0.10)	......	......	......	......	......	0.05	......	......	......	0.31	......	......	0.31	(0.09)	0.31
											17.56			19.06		97.53
13.14	0.17	13.31	84.47	0.01	84.48	......	0.25	0.22	0.01	0.02	1.38	0.06	0.06	1.50	.....	99.29
......	......	......	......	......	......	0.05	0.02	......	......	......	......	......	......	......	......	......
52.95	2.43	55.38	12.77	1.38	14.15	0.12	5.10	2.66	1.44	1.00	16.62	9.00	3.12	28.74	0.65	{ 98.15 98.92
......	......	......	......	......	......	0.13	0.02	......	......	......	......	......	......	......	......	......
						0.25										
45.88	0.57	46.45	45.24	0.15	45.39	......	0.86	0.65	0.10	0.11	4.06	0.63	0.34	5.03	0.23	97.10
......	......	......	......	......	......	2.95	0.14	......	......	......	......	......	......	......	......	......
58.52	3.03	61.55	7.81	0.28	8.09	0.10	5 00	3.87	0.69	0.44	24.19	4.31	1.37	29.87	1.09	100.60
......	......	......	......	......	......	......	0.01	......	......	......	......	......	......	......	......	......
39.27	4.20	43.47	......	.....	0.61	......	8.90	......	......	......	......	......	......	55.63	0.98	100.69

PIG No. 3.—CHESTER WHITE.

37.47	2.94	40.41	16.97	0.21	17.18	0.06	3.16	2.75	0.08	0.33	17.19	0.50	1.03	18.72	21.69	98.00
......	(0.10)	......	......	......	......	......	0.06	......	......	......	0.38	......	......	0.38	(0.06)	0.38
											17.57			19.10		98.38
15.50	.....	......	79.86	.....	......	......	0.33	0.30	0.01	0.02	1.88	0.06	0.06	2.00	.....	97.36
40.78	.....	40.78	31.17	.....	31.17	0.10	4.22	0.72	0.97	2.53	4.50	6.06	7.89	18.45	0.53	90.93
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
55.66	4.46	60.12	10.12	0.29	10.41	0.28	4.82	3.88	0.52	0.42	24.25	3.25	1.31	28.81	0.85	100.19
34.62	4.69	39.31	......	.....	0.70	......	9.64	......	......	.....	......	.....	.....	60.25	0.89	101.15

PIG No. 4.—POLAND CHINA.

40.23	2.47	42.70	9.40	0.47	9.87	0.53	3.40	2.62	0.28	0.50	16.38	1.75	1.56	19.69	25.25	97.51
......	(0.06)	......	......	......	......	......	0.02	......	......	......	0.13	......	......	0.13	(0.03)	0.13
											16.51			19.82		97.64
16.39	0.35	16.74	78.33	0.02	78.35	......	0.44	0.41	0.02	0.01	2.56	0.13	0.03	2.72	.....	97.81
44.49	2.32	46.81	22.10	1.21	23.31	0.25	4.97	1.42	1.83	1.72	8.87	11.44	5.37	25.68	0.63	{88.62 96.43
46.05	0.81	46.86	41.70	1.24	42.94	......	1.12	0.88	0.17	0.07	5.50	1.06	0.22	6.78	0.56	97.14
......	......	......	......	......	......	1.10	0.04	......	......	......	......	......	......	......	......	......
53.34	3.34	56.68	11.44	0.24	11.68	0.10	5.15	3.96	0 88	0.31	24.75	5 50	0.97	31.22	1.48	101.06
......	......	......	......	......	......	......	0.005	......	......	......	......	......	......	......	......	......
43.45	4.07	47.52	......	.....	0.60	......	8.37	......	......	......	......	......	......	52.31	0.81	101.24

TABLE No. 5.—*Analytical data for bones,*

PIG No. 5.—DUROC JERSEY.

Serial No.	Names of parts.	Air-dry sample, per cent of original material.	Per cent air-dry material.							
					Nitrogen.					
			Water.	Fat.	Total.	Of proteids insoluble in hot water.	Precipitated by bromin.	Of flesh bases.	Lecithin.	Ash.
16600	Bones	53.64	4.69	0.86	6.77	5.93	0.17	0.67	0.93	49.70
16600A	(Fat extracted with ether)	11.58	7.30		0.34					(0.61)
16601	Marrow	6.25	6.73	0.28	8.26	7.30	0.45	0.51		
16603	Skin	*a* 26.35	5.08	5.46	15.13	2.22	6.91	6.00	0.33	1.82
16605	Spinal cord	18.07	6.54	0.07	9.26	7.58	0.84	0.84		
16607	Tendons *b*									
17181	Hoofs	70.03	7.33	1.05	14.77					1.22

PIG No. 6.—DUROC JERSEY.

Serial No.	Names of parts.	Air-dry sample, per cent of original material.	Water.	Fat.	Nitrogen: Total.	Of proteids insoluble in hot water.	Precipitated by bromin.	Of flesh bases.	Lecithin.	Ash.
16748	Bones	51.74	5.79	0.31	6.46	5.39	0.31	0.76		50.36
16748A	(Fat extracted with ether)	17.48	(0.43)		0.21					(0.23)
16751	Marrow *c*		4.83	0.27	8.14	6.89	0.56	0.69		
16746	Skin	*a* 34.21	7.78	3.63	14.83	6.32	2.81	5.70	0.18	1.83
16749	Spinal cord *c*				9.97	7.72	1.12	1.13		
17162	(Fat extracted with ether)	34.91			0.20				8.12	
16753	Tendons	34.51	9.78	0.21	15.05	11.71	2.13	1.21	0.24	2.79
17173	(Fat extracted with ether)	4.11			0.12					
17182	Hoofs	58.83	5.97	1.18	14.55					1.73

PIG No. 7—DUROC JERSEY.

Serial No.	Names of parts.	Air-dry sample, per cent of original material.	Water.	Fat.	Nitrogen: Total.	Of proteids insoluble in hot water.	Precipitated by bromin.	Of flesh bases.	Lecithin.	Ash.
16775	Bones	53.50	6.52	0.66	6.44	5.59	0.17	0.68	0.15	50.59
16775A	(Fat extracted with ether)	12.88	3.63		0.32				2.72	
16776	Marrow *c*		6.35	0.48	7.02	6.32	0.56	0.14		
16778	Skin	39.18	9.80	3.78	14.69	7.84	4.13	2.72	0.20	2.00
17148	(Fat extracted with ether)	11.95			0.18				0.55	
16780	Spinal cord	12.76	6.43	0.76	9.55	7.58	1.26	0.71		
17167	(Fat extracted with ether)	50.36			0.37				5.50	
16782	Tendons	31.94	11.65	0.47	14.43	11.49	1.96	0.98	0.36	2.71
17183	Hoofs	60.06	6.96		14.83					

PIG No. 8.—YORKSHIRE.

Serial No.	Names of parts.	Air-dry sample, per cent of original material.	Water.	Fat.	Nitrogen: Total.	Of proteids insoluble in hot water.	Precipitated by bromin.	Of flesh bases.	Lecithin.	Ash.
16804	Bones	50.51	11.16	0.68	6.60	5.73	0.28	0.59	0.40	50.08
16804A	(Fat extracted with ether)	13.74	(0.53)		0.29					(0.26)
16805	Marrow	4.41	6.21	0.19	7.75	6.85	0.79	0.11		
17153	(Fat extracted with ether)	29.28			0.04				0.22	
16807	Skin *c*									
16809	Spinal cord *c*									
17161	(Fat extracted with ether)	30.30			0.27				5.29	
16811	Tendons		11.65	0.67	13.96	12.29	1.43	0.24	0.24	2.96
17184	Hoofs	51.03	6.44	0.96	14.65					1.39

a Fat-free and water-free. *b* Sample lost. *c* Lost.

marrow, skin, spinal cord, tendons, and hoofs—Continued.

PIG No. 5.—DUROC JERSEY.

Per cent original material.																
Water.			Fat.			Lecithin.	Nitrogen.				Nitrogenous substances.				Ash.	Total.
In preparing sample.	In original material.	Total.	In preparing sample.	In original material.	Total.		Total.	Of proteids insoluble in hot water.	Precipitated by bromin.	Of flesh bases.	Proteids insoluble in hot water.	Gelatinoids.	Flesh bases.	Total.		
34.78	2.52	36.45	1.58	0.46	12.89	0.50	3.63	3.18	0.09	0.36	19.88	0.56	1.12	21.56	26.66	97.56
......	0.85	......	......	.....	......	......	0.04	......	.....	.....	0.25	.....	.....	0.25	(0.07)	0.25
											20.13			21.81		97.81
12.80	0.42	13.22	80.95	0.02	80.97	......	0.52	0.46	0.03	0.03	2.88	0.19	0.09	3.16	.....	97.35
......	.....	35.49	......	.....	38.16	0.09	3.99	0.59	1.82	1.58	3.69	11.38	4.93	20.00	0.48	94.13
58.32	1.18	59.50	23.61	0.01	23.62	......	1.67	1.37	0.15	0.15	8.56	0.94	0.47	9.97	.....	93.09
......	.....	......	......	.....	......	......	.....	......	.....	.....	......	.....	.....	......	.....	....
29.97	5.13	35.10	......	.....	0.74	......	10.34	......	.....	.....	......	.....	.....	64.63	0.85	101.32

PIG No. 6.—DUROC JERSEY.

30.78	3.00	33.78	17.48	0.16	17.64	......	3.34	2.79	0.16	0.39	17.44	1.00	1.22	19.66	26.06	97.14
......	(0.08)	......	......	.....	......	......	0.04	......	.....	.....	0.25	.....	.....	0.25	(0.04)	0.25
											17.69			19.91		97.39
......	.....	......	......	.....	......	......	.....	......	.....	.....	......	.....	.....	......	.....	....
......	.....	45.20	......	.....	20.59	0.06	5.07	2.16	0.96	1.95	13.50	6.00	6.08	25.58	0.63	92.00
......	.....	......	......	.....	......	......	.....	......	.....	.....	......	.....	.....	......	.....	....
......	.....	......	......	.....	......	2.51	0.07	......	.....	.....	......	.....	.....	......	.....	....
56.24	3.38	59.62	9.25	0.07	9.32	0.08	5.20	4.04	0.74	0.42	25.25	4.63	1.31	31.19	0.96	101.09
......	.....	......	......	.....	......	......	0.005	......	.....	.....	......	.....	.....	......	.....	....
41.17	3.51	44.68	......	.....	0.69	......	8.56	......	.....	.....	......	.....	....	53.50	1.02	99.89

PIG No. 7.—DUROC JERSEY.

33.62	3.49	......	12.88	0.35	......	0.08	3.45	2.99	0.09	0.37	18.69	0.56	1.15	20.40	27.07	97.81
......	0.47	36.64	......	.....	13.70	0.35	0.04	......	.....	.....	0.25	.....	.....	0.25	(0.04)	0.25
						0.43					18.94			20.65		98.06
......	.....	......	......	.....	......	......	.....	......	.....	.....	......	.....	.....	......	.....	....
46.55	.....	50.39	14.27	.....	15.75	0.08	5.76	3.07	1.62	1.07	19.19	10.13	3.34	32.66	0.78	{ 99.09 { 99.58
......	3.84	......	......	1.48	......	0.07	.....	......	.....	.....	......	.....	.....	......	.....	....
						0.15										
20.02	0.82	20.84	67.22	0.10	67.32	......	1.22	0.97	0.16	0.09	6.06	1.00	0.28	7.34	.....	95.50
......	.....	......	......	.....	......	0.70	0.19	......	.....	.....	......	.....	.....	......	.....	....
54.19	3.72	57.91	13.87	0.15	14.02	0.11	4.61	3.67	0.63	0.31	22.94	3.94	0.97	27.85	0.87	100.65
39.94	4.18	44.12	......	.....	......	......	8.91	......	.....	.....	......	.....	.....	55.69	.....	....

PIG No. 8.—YORKSHIRE.

35.75	5.64	41.39	13.74	0.34	14.08	0.20	3.33	2.89	0.14	0.30	18.07	0.87	0.94	19.88	25.30	100.65
......	(0.07)	......	......	.....	......	......	0.04	......	.....	.....	0.25	.....	.....	0.25	(0.04)	0.25
											18.32			20.13		100.90
14.02	0.27	14.29	81.57	0.01	81.58	......	0.34	0.30	0.03	0.01	1.88	0.19	0.03	2.10	.....	97.97
......	.....	......	......	.....	......	0.06	0.01	......	.....	.....	......	.....	.....	......	.....	....
......	.....	......	......	.....	......	......	.....	......	.....	.....	......	.....	.....	......	.....	....
......	.....	......	......	.....	......	......	.....	......	.....	.....	......	.....	.....	......	.....	....
......	.....	......	......	.....	......	1.60	0.08	......	.....	.....	......	.....	.....	......	.....	....
48.97	3.29	52.26	......	.....	0.49	......	7.48	......	.....	.....	......	.....	.....	46.75	0.71	100.21

TABLE NO. 6—*Revised analytical data.*

PIG No. 1.—BERKSHIRE.

[Per cents original material.]

Serial No.	Names of cuts and parts.	Water.	Fat.	Nitrogenous substances.				Lecithin.a	Ash.	Total.
				Proteids, insoluble in hot water.	Gelatinoids.	Flesh bases.	Total.			
	Meat:									
16667	American backs	32.27	57.69	7.00	0.50	0.91	8.41	0.15	0.51	99.03
16669	American bellies	37.27	51.93	7.00	0.56	1.22	8.78	0.14	0.55	98.67
16671	Short-cut hams	*b* 60.29	22.19	14.00	0.69	1.15	15.84	0.65	0.96	99.93
16673	New York shoulders	*b* 54.97	29.01	11.25	0.81	1.56	13.62	0.15	0.89	98.64
16675	Four feet	61.28	16.83	12.19	4.69	2.34	19.22	0.61	0.82	98.76
16677	Spareribs	52.54	29.10	13.44	1.13	1.19	15.76	0.35	1.00	98.75
16679	Tenderloins	68.06	8.78	18.56	0.50	1.06	20.12	0.49	1.17	98.62
16680	Neck bones	55.70	27.92	12.44	0.75	1.06	14.25	0.68	0.81	99.36
16682	Backbones	52.83	27.22	14.38	0.87	1.44	16.69	0.26	1.24	98.24
16684	Trimmings	*b* 29.68	62.00	5.19	0.69	1.03	6.91	0.11	0.41	99.11
16686	Tail	24.02	68.23	5.75	0.56	0.50	6.81	0.17	0.39	99.62
16690	Bones	38.94	11.67	17.50	0.38	1.25	19.13	0.44	26.12	96.30
16691	Marrow	14.36	81.51	2.00	0.19	0.06	2.25	*c* 0.46	....	98.58
16688	Skin	50.24	17.11	25.25	6.69	1.37	33.31	0.41	0.63	101.70
16693	Spinal cord	65.70	26.76	3.88	0.69	0.16	4.73	*d* 1.47	*e* 0.40	97.19
16695	Tendons	58.43	13.40	22.44	4.44	0.62	27.50	0.45	1.18	100.96
17177	Hoofs	41.09	0.86	....	....	....	58.00	....	0.93	100.88

PIG No. 2.—TAMWORTH.

	Meat:									
16696	American backs	*b* 29.13	61.76	5.75	0.69	0.91	7.35	0.13	0.43	98.80
16698	American bellies	33.69	56.52	7.00	0.63	0.91	8.54	0.15	0.47	99.37
16700	Short-cut hams	*b* 57.93	24.45	13.00	0.63	1.25	14.88	0.22	0.84	98.32
16702	New York shoulders	*b* 35.07	20 29.98	11.25	0.87	1.19	13.31	0.24	0.79	99.39
16704	Four feet	*b* 58.66	21.23	11.63	3.38	2.96	17.97	0.51	0.86	99.23
16706	Spareribs	49.20	33.88	11.56	1.31	1.40	14.27	0.25	0.93	98.53
16708	Tenderloins	65.52	13.51	17.13	0.56	0.91	18.60	0.91	1.06	99.60
16709	Neck bones	55.52	26.03	13.38	1.31	1.40	16.09	0.83	1.02	99.49
16711	Backbones	51.06	30.67	13.69	0.87	1.22	15.78	0.25	1.10	98.86
16713	Trimmings	28.85	62.67	5.31	0.81	1.03	7.15	0.10	0.43	99.20
16715	Tail	25.77	67.08	4.25	0.69	0.78	5.72	0.10	0.30	98.97
16719	Bones	38.06	15.06	17.56	0.69	0.81	19.06	0.04	25.35	97.57
16720	Marrow	13.31	84.48	1.38	0.06	0.06	1.50	*f* 0.05	....	99.34
16717	Skin	55.38	14.15	16.62	9.00	3.12	28.74	0.25	0.65	99.17
16722	Spinal cord	46.45	45.39	4.06	0.63	0.34	5.03	*f* 2.95	0.23	100.05
16724	Tendons	61.55	8.09	24.19	4.31	1.37	29.87	0.10	1.09	100.70
17178	Hoofs	43.47	0.61	....	....	....	55.63	....	0.98	100.69

PIG No. 3.—CHESTER WHITE.

	Meat:									
16609	American backs	*b* 23.72	70.16	4.50	0.44	0.75	5.69	0.12	0.35	100.04
16611	American bellies	30.54	60.73	5.44	0.63	1.03	7.10	0.08	0.42	98.87
16613	Short-cut hams	53.15	30.99	11.13	0.63	1.97	13.73	0.35	0.80	99.02
16615	New York shoulders	*b* 49.16	37.62	9.44	0.87	1.34	11.65	0.28	0.71	99.42
16617	Four feet	*b* 53.05	26.74	9.88	6.38	1.06	17.32	0.19	0.84	98.04
16619	Spareribs	53.23	27.93	13.63	0.87	1.65	16.15	0.28	0.92	98.51
16621	Tenderloins	65.97	13.47	16.69	0.44	1.03	18.16	0.40	1.06	99.06
16622	Neck bones	53.50	29.52	12.19	0.75	1.31	14.25	0.25	0.87	98.39
16624	Backbones	50.39	31.65	13.38	0.56	1.34	15.28	0.23	1.05	98.60
16626	Trimmings	22.49	71.55	3.25	0.50	0.84	4.59	0.07	0.31	99.01
16628	Tail	*b* 15.66	79.69	3.00	0.44	0.62	4.06	0.08	0.24	99.73
16630	Bones	40.41	17.18	17.57	0.50	1.03	19.10	0.06	21.69	98.44
16631	Marrow	15.50	79.86	1.88	0.06	0.06	2.00	*c* 0.19	....	97.42
16633	Skin	*b* 40.78	31.17	4.50	6.06	7.89	18.45	0.10	0.53	91.03
16635	Spinal cord	*e* 48.27	*e* 41.21	*e* 5.61	*e* 0.86	*e* 0.30	*e* 6.77	*c* 1.47	*e* 0.40	98.12
16637	Tendons	60.12	10.41	24.25	3.25	1.31	28.81	0.28	0.85	100.47
17179	Hoofs	39.31	0.70	....	....	....	60.25	....	0.89	101.15

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a Lecithin in extracted sample only, unless otherwise noted.

b Result of direct determination on original material. Other numbers in this column represent the sum of the per cent of water removed in the preparation of sample and the per cent of water remaining in the air-dry sample.

c In fat extract.

d In fat extract, calculated from averages for like cuts.

e Calculated from averages of like cuts.

f In residue and fat extract.

TABLE No. 6—*Revised analytical data*—Continued.

PIG No. 4.—POLAND CHINA.

[Per cents original material.]

Serial No.	Names of cuts and parts.	Water.	Fat.	Nitrogenous substances.				Lecithin. *a*	Ash.	Total.
				Proteids, insoluble in hot water.	Gelatinoids.	Flesh bases.	Total.			
	Meat:									
16638	American backs	26.13	66.33	5.13	0.56	0.81	6.50	*a*0.21	0.38	99.34
16640	American bellies	30.78	60.69	4.81	0.63	1.10	6.63	0.12	0.43	98.65
16642	Short-cut hams	54.78	30.12	10.69	0.81	1.28	12.78	0.23	0.76	98.67
16644	New York shoulders	*b*51.72	33.74	7.81	0.63	0.94	9.38	0.30	0.59	95.73
16646	Four feet	50.66	31.32	11.00	4.19	0.97	16.16	0.15	0.91	99.20
16648	Spareribs	*b*52.95	29.55	10.06	0.63	3.09	13.78	0.31	0.95	97.54
16650	Tenderloins	67.43	10.95	17.63	0.69	0.78	19.10	0.39	1.13	99.00
16651	Neck bones	55.23	28.27	10.25	1.13	1.75	13.13	0.45	0.91	97.99
16653	Backbones	*b*51.26	30.98	12.94	0.81	1.34	15.09	0.27	1.05	98.65
16655	Trimmings	22.43	71.52	3.69	0.44	0.69	4.82	0.06	0.32	99.15
16657	Tail	16.50	77.77	3.44	0.56	0.66	4.66	0.09	0.31	99.33
16663	Bones	42.70	9.87	16.51	1.75	1.56	19.82	0.53	25.25	98.17
16665	Marrow	16.74	78.35	2.56	0.13	0.03	2.72	*c*0.19	....	97.87
16659	Skin	46.81	23.31	8.87	11.44	5.37	25.68	0.25	0.63	96.68
16661	Spinal cord	48.86	42.94	5.50	1.06	0.22	6.78	1.10	0.56	100.24
16664	Tendons	56.68	11.68	24.75	5.50	0.97	31.22	0.10	1.48	101.16
17180	Hoofs	47.52	0.60	....	....	....	52.31	....	0.81	101.24

PIG No. 5.—DUROC JERSEY.

	Meat:									
16579	American backs	*b*20.75	73.25	3.94	0.50	0.84	5.28	0.08	0.29	99.65
16581	American bellies	29.13	62.83	5.06	0.56	1.00	6.62	0.10	0.42	99.10
16583	Short-cut hams	50.45	35.94	8.38	1.00	0.50	9.88	0.03	0.71	97.01
16585	New York shoulders	*b*44.16	43.74	7.63	0.63	1.09	9.35	0.10	0.55	97.90
16587	Four feet	*b*54.16	26.19	10.19	2.19	2.90	15.28	*a*0.32	0.76	96.39
16589	Spareribs	54.09	26.90	14.06	0.81	1.53	16.40	0.12	1.04	98.55
16591	Tenderloins	66.55	11.41	18.31	0.38	1.09	19.78	0.35	1.14	99.23
16592	Neck bones	52.48	30.31	12.50	0.75	1.40	14.65	0.20	0.94	98.58
16594	Backbones	48.77	29.40	16.38	0.81	1.65	18.84	0.41	1.23	98.65
16596	Trimmings	20.08	74.13	3.25	0.44	0.87	4.56	0.08	0.30	99.15
16598	Tail	11.54	84.62	2.00	0.31	0.62	2.93	0.07	0.20	99.36
16600	Bones	36.45	12.89	20.13	0.56	1.12	21.81	0.50	26.66	98.31
16601	Marrow	13.22	80.97	2.88	0.19	0.09	3.16	*d*0.19	....	97.41
16603	Skin	*b*35.49	38.16	3.69	11.38	4.93	20.00	0.09	0.48	94.22
16605	Spinal cord	59.50	23.62	8.56	0.94	0.47	9.97	1.47	*a*0.40	93.09
16607	Tendons	*a*59.05	*a*11.15	*a*23.97	*a*4.35	*a*1.09	*a*29.41	*a*0.19	*a*1.07	100.68
17181	Hoofs	35.10	0.74	....	....	....	64.63	....	0.85	101.32

PIG No. 6.—DUROC JERSEY.

	Meat:									
16725	American backs	20.32	73.63	3.75	0.44	0.72	4.91	0.20	0.29	99.35
16727	American bellies	34.52	58.97	4.38	0.56	0.59	5.53	0.12	0.22	99.36
16729	Short-cut hams	37.26	39.10	17.38	1.25	1.69	20.32	0.35	1.32	98.35
16731	New York shoulders	39.46	49.18	7.50	0.94	1.06	9.50	0.12	0.84	99.10
16733	Four feet	51.84	29.47	10.56	2.88	2.31	15.75	0.35	0.75	98.16
16735	Spareribs	49.84	31.95	13.63	1.13	1.09	15.85	0.33	1.10	99.07
16737	Tenderloins	63.86	14.81	17.31	0.63	0.87	18.81	0.56	1.05	99.09
16738	Neck bones	49.30	34.92	11.69	0.94	1.06	13.69	0.28	0.87	99.06
16740	Backbones	*b*47.54	35.96	12.81	1.06	1.15	15.02	0.36	0.92	99.80
16742	Trimmings	16.51	78.78	3.06	0.38	0.50	3.94	0.07	0.25	99.54
16744	Tail	13.94	81.23	3.00	0.44	0.41	3.85	0.06	0.23	99.31
16748	Bones	33.78	17.64	17.69	1.00	1.22	19.91	*a*0.31	26.06	97.39
16751	Marrow	*a*14.57	*a*81.13	*a*2.09	*a*0.14	*a*0.06	*a*2.29	*d*0.19	....	97.99
16746	Skin	*b*45.20	20.50	13.50	6.00	6.08	25.58	0.06	0.63	92.06
16749	Spinal cord	*a*48.27	*a*41.21	*a*5.61	*a*0.86	*a*0.30	*a*6.77	*e*2.51	*a*0.40	99.16
16753	Tendons	59.62	9.32	25.25	4.63	1.31	31.19	0.08	0.96	101.17
17182	Hoofs	44.68	0.69	....	....	....	53.50	....	1.02	99.89

a Calculated from averages of like cuts.

b Result of direct determination on original material. Other numbers in this column represent the sum of the per cent of water removed in the preparation of sample and the per cent of water remaining in the air-dry sample.

c In fat extract.

d In residue and fat extract, calculated from averages of like cuts.

e In residue and fat extract.

TABLE No. 6.—*Revised analytical data*—Continued.

PIG No. 7.—DUROC JERSEY.

[Per cents original material.]

Serial No.	Names of cuts and parts.	Water.	Fat.	Nitrogenous substances.				Lecithin.a	Ash.	Total.
				Proteids, insoluble in hot water.	Gelatinoids.	Flesh bases.	Total.			
	Meat:									
16754	American backs	20.23	73.95	4.06	0.56	0.50	5.12	0.48	0.29	100.07
16756	American bellies	*a* 21.53	73.56	2.81	0.38	0.31	3.50	0.48	0.21	99.28
16758	Short-cut hams	*a* 44.26	43.38	9.56	0.87	0.81	11.24	0.45	0.65	99.98
16760	New York shoulders	44.62	42.65	9.06	0.94	0.87	10.87	0.62	0.91	99.67
16762	Four feet	55.98	25.25	12.38	2.63	1.53	16.54	0.36	0.78	98.91
16764	Spareribs	53.20	27.51	14.56	1.13	1.09	16.78	0.83	1.01	99.33
16766	Tenderloins	72.83	9.35	14.69	0.50	0.56	15.75	0.32	0.86	99.11
16767	Neck bones	52.10	30.92	12.38	1.13	0.62	14.13	0.55	0.94	98.64
16769	Backbones	53.09	28.07	13.88	1.06	1.19	16.13	0.44	1.02	98.75
16771	Trimmings	20.49	73.56	3.38	0.63	0.75	4.76	*b* 0.11	0.28	99.20
16773	Tail	13.73	81.74	2.81	0.50	0.44	3.75	0.48	0.27	99.97
16775	Bones	36.64	13.70	18.94	0.56	1.15	20.65	0.43	27.07	98.49
16776	Marrow	*c* 14.57	*c* 81.13	*c* 2.09	*c* 0.14	*c* 0.06	*c* 2.29	*d* 0.19	......	97.99
16778	Skin	50.39	15.75	19.19	10.13	3.34	32.66	0.15	0.78	99.73
16780	Spinal cord	20.84	67.32	6.06	1.00	0.28	7.34	*b* 0.70	*c* 0.40	96.20
16782	Tendons	57.91	14.02	22.94	3.94	0.97	27.85	0.11	0.87	100.76
17183	Hoofs	44.12	*e* 0.67	......	......	......	55.69	......	*c* 0.89	101.37

PIG No. 8.—YORKSHIRE.

	Meat:									
16783	American backs	28.55	62.53	5.94	1.06	0.62	7.62	0.32	0.41	99.43
16785	American bellies	33.79	56.22	6.75	1.25	0.66	8.66	0.25	0.48	99.40
16787	Short-cut hams	59.14	25.23	11.50	0.87	1.09	13.46	0.42	0.74	98.99
16789	New York shoulders	*a* 49.57	36.09	8.50	0.87	1.09	10.46	0.17	0.63	96.92
16791	Four feet	*a* 57.47	30.86	5.13	1.63	1.53	8.29	0.08	0.41	97.11
16793	Spareribs	52.31	29.28	13.56	1.13	1.34	16.03	0.33	1.05	99.00
16795	Tenderloins	66.65	13.07	16.00	0.81	1.03	17.84	0.68	1.04	99.28
16796	Neck bones	55.13	26.71	13.31	1.00	1.15	15.46	0.54	0.99	98.83
16798	Backbones	50.65	29.61	14.13	1.25	1.28	16.66	0.78	1.18	98.88
16800	Trimmings	26.12	65.81	4.56	1.00	0.94	6.50	0.44	0.39	99.26
16802	Tail	18.50	74.37	4.88	1.06	0.41	6.35	0.55	0.33	100.10
16804	Bones	41.39	14.08	18.32	0.87	0.94	20.13	0.20	25.30	101.10
16805	Marrow	14.29	81.58	1.88	0.19	0.03	2.10	*b* 0.06	......	98.03
16807	Skin	*c* 46.33	*c* 22.88	*c* 13.09	*c* 8.67	*c* 4.59	*c* 26.35	*c* 0.19	*c* 0.62	96.18
16809	Spinal cord	*c* 48.27	*c* 41.21	*c* 5.61	*c* 0.86	*c* 0.30	*c* 6.77	*e* 1.47	*c* 0.40	96.73
16811	Tendons	*c* 59.05	*c* 11.15	*c* 23.97	*c* 4.35	*c* 1.09	*c* 29.41	*c* 0.19	*c* 1.07	100.68
17184	Hoofs	52.26	0.40	......	......	......	46.75	......	0.71	100.21

a Result of direct determination on original material. Other numbers in this column represent the sum of the per cent of water removed in the preparation of sample and the per cent of water remaining in the air-dry sample.

b In residue and fat extract.

c Calculated from averages of like cuts.

d In fat extract, calculated from averages for like cuts.

e In fat extract.

TABLE NO. 7.—*Data for the entire dressed animal; the head, leaf lard, and kidneys having been removed.*

PIG No. 1.—BERKSHIRE.

Serial No.	Names of parts.	Weight of parts—		Of entire pig.	Weight of each constituent.							
		From each cut.	Total.		Water.	Fat.	Nitrogenous substances.				Lecithin.	Ash.
							Proteids, insoluble in hot water.	Gelatinoids.	Flesh bases.	Total.		
	Meat (fat and lean):	*Grams.*	*Grams.*	*Per cent.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams*
16667	Backs	14,767.9	....	....	4,765.6	8,519.6	1,033.8	73.8	134.4	1,242.0	22.15	75.3
16669	Bellies	8,230.6	....	....	3,067.5	4,274.2	576.1	46.1	100.4	722.6	11.52	45.3
16671	Hams	9,407.9	....	....	5,672.0	2,087.6	1,317.2	64.9	108.2	1,490.3	61.15	90.3
16673	Shoulders	8,448.2	....	....	4,644.2	2,450.6	950.4	68.4	131.8	1,150.6	12.67	75.2
16675	Feet	325.3	....	....	199.3	54.7	39.6	15.3	7.6	62.5	1.98	2.7
16677	Spareribs	1,683.8	....	....	884.7	490.0	226.4	19.0	20.0	265.4	5.89	16.8
16679	Tenderloins	470.8	....	....	320.4	41.3	87.4	2.3	5.0	94.7	2.31	5.5
16680	Neck bones	493.2	....	....	274.7	137.7	61.4	3.7	5.2	70.3	3.35	4.0
16682	Backbones	704.0	....	....	371.9	191.7	101.3	6.1	10.1	117.5	1.83	8.7
16684	Trimmings	7,021.5	....	....	2,084.0	4,353.1	364.4	48.4	72.3	485.1	7.72	28.8
16686	Tail	291.7	....	....	70.1	199.1	16.8	1.6	1.5	19.9	0.50	1.1
	Total for meats	....	51,844.9	88.19	22,354.4	22,799.6	4,774.8	349.6	596.5	5,720.9	131.07	353.7
16690	Bones (less marrow)	....	4,374.7	7.44	1,703.6	510.6	765.6	16.6	54.7	836.9	19.25	1,142.6
16691	Marrow	....	69.7	0.12	10.0	56.8	1.4	0.2	0.1	1.7	*a* 0.32	....
16688	Skin	....	2,232.5	3.80	1,121.6	381.9	563.7	149.4	30.6	743.7	9.15	14.1
16693	Spinal cord	....	55.7	0.09	36.6	14.9	2.2	0.4	0.1	2.7	*b* 0.82	*c* 0.2
16695	Tendons	....	159.5	0.27	93.2	21.4	35.8	7.1	1.0	43.9	0.72	1.9
17177	Hoofs	....	52.6	0.09	21.6	0.4	....	....	....	80.5	....	0.5
	Total weights	....	58,789.6	....	25,341.0	23,785.6	6,143.5	523.3	683.0	7,654.9	161.33	151.3
	Total per cents of original material	....	....	....	43.10	40.46	10.45	0.89	1.16	13.02	0.27	2.57

a In fat extract.

b In residue and fat extract, calculated from averages of like cuts.

c Calculated from averages of like cuts.

TABLE NO. 7.—*Data for the entire dressed animal; the head, leaf lard, and kidneys having been removed*—Continued.

PIG No. 2.—TAMWORTH.

Serial No.	Name of parts.	Weight of parts—		Of entire pig.	Weight of each constituent.							
							Nitrogenous substances.					
		From each cut.	Total.		Water.	Fat.	Proteids, insoluble in hot water.	Gelatinoids.	Flesh bases.	Total.	Lecithin.	Ash.
	Meat (fat and lean):	*Grams.*	*Grams.*	*Per cent.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
16696	Backs	17,201.7			5,010.9	10,624.5	989.2	118.7	156.6	1,264.5	22.36	74.0
16698	Bellies	8,281.8			2,790.0	4,680.9	579.7	52.2	75.4	707.3	12.42	38.9
16700	Hams	10,110.2			5,856.8	2,471.9	1,314.2	63.7	126.4	1,504.3	22.24	84.9
16702	Shoulders	8,256.6			4,546.0	2,475.0	928.8	71.8	98.2	1,098.8	19.82	65.2
16704	Feet	452.3			265.3	96.0	52.6	15.3	13.4	81.3	2.31	3.9
16706	Spareribs	1,575.7			775.3	533.9	182.2	20.6	22.1	224.9	3.94	14.7
16708	Tenderloins	528.2			346.1	71.4	90.5	3.0	4.8	98.3	4.81	5.6
16709	Neck bones	459.5			255.1	119.6	61.5	6.0	6.4	73.9	3.81	4.7
16711	Backbones	860.2			439.2	263.8	117.8	7.5	10.5	135.8	2.05	9.5
16713	Trimmings	6,979.4			2,013.6	4,374.0	370.6	56.5	71.9	499.0	0.70	30.0
16715	Tail	599.5			154.5	402.2	25.5	4.1	4.7	34.3	0.60	1.8
	Total for meats		55,305.1	86.50	22,453.7	26,113.2	4,712.6	419.4	590.4	5,722.4	95.06	333.2
16719	Bones (less marrow)		5,231.8	8.18	1,991.2	787.9	918.7	36.1	42.4	997.2	2.09	1,326.1
16720	Marrow		133.9	0.21	17.8	113.1	1.9	0.1	0.1	2.0	0.07	
16717	Skin		3,011.6	4.71	1,667.9	426.2	500.3	271.1	94.0	865.4	7.53	19.6
16722	Spinal cord		60.8	0.09	28.2	27.6	2.5	0.4	0.2	3.1	1.79	0.1
16724	Tendons		138.7	0.21	85.4	11.2	33.6	6.0	1.9	41.5	0.14	1.5
17178	Hoofs		64.5	0.10	28.0	0.4				35.9		0.6
	Total weights		63,946.4		26,272.2	27,479.6	6,169.6	733.1	729.0	7,667.5	106.68	1,681.1
	Total per cents of original material			100.00	41.09	42.97	9.65	1.15	1.14	11.99	0.17	2.63

PIG No. 3.—CHESTER WHITE.

	Meat (fat and lean):											
16609	Backs	15,217.9			3,609.9	10,676.9	684.9	66.9	114.1	866.0	18.26	53.3
16611	Bellies	8,966.6			2,738.4	5,445.1	487.8	56.5	92.4	636.7	7.17	37.7
16613	Hams	7,765.3			4,127.8	2,406.7	864.4	48.9	153.0	1,066.3	27.19	62.1
16615	Shoulders	8,408.4			4,163.1	3,185.9	799.4	73.7	113.5	986.6	23.71	60.1
16617	Feet	269.1			142.8	72.0	26.6	17.2	2.8	46.6	0.49	2.3

16619	Spareribs	1,012.8			539.1	282.9	138.1	8.8	16.7	163.6	2.84	9.3
16621	Tenderloins	453.6			299.5	61.1	75.7	2.0	4.7	82.4	1.81	4.8
16622	Neck bones	427.1			228.5	126.1	52.1	3.2	5.6	60.9	1.07	3.7
16624	Backbones	584.5			249.5	185.0	78.2	3.3	7.8	89.3	1.34	6.2
16626	Trimmings	6,398.9			1,439.1	4,578.2	208.0	32.0	53.7	293.7	4.48	19.8
16628	Tail	633.9			99.3	505.2	19.0	2.8	3.9	25.7	0.51	1.5
	Total for meats		50,198.1	87.94	17,636.5	27,525.1	3,434.2	315.3	568.2	4,317.8	88.87	260.8
16630	Bones (less marrow)		3,545.2	6.21	1.432.6	609.1	623.0	17.7	36.5	677.2	2.13	769.0
16631	Marrow		43.6	0.08	6.8	34.8	0.8	0.03	0.03	0.9	*a* 0.08	
16633	Skin		3,150.2	5.52	1,284.7	982.0	141.8	190.9	248.6	581.3	3.15	16.7
16635	Spinal cord		39.0	0.07	(18.8)	(16.1)	(2.2)	(0.3)	(0.1)	(2.6)	*b* 0.57	0.2
16637	Tendons		67.2	0.12	40.4	7.0	16.3	2.2	0.9	19.4	0.19	0.6
17179	Hoofs		37.0	0.06	14.5	0.3				22.3		0.3
	Total weights		57,080.3		20,434.3	29,174.4	4,218.3	526.43	854.33	5,621.5	94.99	1,047.6
	Total per cent of original material			100.00	35.80	51.11	7.39	0.92	1.50	9.85	0.17	1.84

PIG No. 4.—POLAND CHINA.

	Meat (fat and lean):											
16638	Backs	16,830.2			4,397.9	11,162.4	863.4	94.3	136.3	1,094.0	(35.34)	64.0
16640	Bellies	10,151.8			3,124.7	6,161.0	488.3	64.0	120.8	673.1	12.18	43.7
16642	Hams	10,636.0			5 826.4	3,203.6	1137.1	86.2	136.1	1,359.4	4.46	80.8
16644	Shoulders	9,735.5			5,035.2	3,284.6	760.4	61.3	91.5	913.2	29.21	57.4
16646	Feet	466.6			236.4	146.2	51.3	19.6	4.5	75.4	0.70	4.2
16648	Spareribs	1,522.4			806.2	449.9	153.2	9.6	47.0	209.8	4.72	14.5
16650	Tenderloins	419.8			283.2	46.0	74.0	2.9	3.3	80.2	1.64	4.7
16651	Neck bones	537.9			297.1	152.1	55.1	6.1	9.4	70.6	2.42	5.0
16653	Backbones	636.6			326.6	197.2	82.4	5.2	8.5	96.1	1.72	6.7
16655	Trimmings	8,574.3			1,923.2	6,132.2	316.4	37.7	59.2	413.3	5.15	27.4
16657	Tail	671.6			110.8	522.3	23.1	3.8	4.4	31.3	0.60	2.1
	Total for meats		60,182.7	90.67	22,367.7	31,457.5	4,004.7	390.7	621.0	5,016.4	98.14	310.5
16663	Bones (less marrow)		3,519.0	5.30	1,502.6	347.7	581.1	61.6	54.9	697.6	18.65	888.7
16665	Marrow		72.0	0.11	12.1	56.4	1.8	0.1	0.02	1.92	*a* 0.14	
16659	Skin		2,406.8	3.63	1,126.6	561.0	213.5	275.4	129.3	618.2	6.02	15.2
16661	Spinal cord		51.1	0.08	25.0	21.9	2.8	0.5	0.1	3.4	0.56	0.3
16664	Tendons		96.0	0.14	54.4	11.2	23.8	5.3	0.9	30.0	0.10	1.4
17180	Hoofs		44.9	0.07	21.3	0.3				23.5		0.4
	Total weights		66,372.5		25,109.7	32,456.0	4,827.7	733.6	806.22	6,408.3	123.61	1,216.5
	Total per cent of original material			100.00	37.83	48.90	7.27	1.11	1.21	9.66	0.19	1.83

a In fat extract, calculated from averages for like cuts.

b In residue and fat extract, calculated from averages of like cuts.

TABLE No. 7.—*Data for the entire dressed animal; the head, leaf lard, and kidneys having been removed*—Continued.

PIG No. 5.—DUROC JERSEY.

Serial No.	Names of parts.	Weight of parts—		Of entire pig.	Weight of each constituent.							
		From each cut.	Total.		Water	Fat.	Nitrogenous substances.				Lecithin.	Ash.
							Proteids, insoluble in hot water.	Gelatinoids.	Flesh bases.	Total.		
	Meat (fat and lean):	*Grams.*	*Grams.*	*Per cent.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
16579	Backs	16,709.2	....	....	3,467.2	12,238.5	658.4	83.5	140.4	882.3	13.37	48.5
16581	Bellies	10,189.1	....	....	2,968.1	6,402.1	515.6	57.1	101.9	674.6	10.19	42.8
16583	Hams	8,396.1	....	....	4,235.8	3,017.9	703.6	84.0	42.0	829.6	2.52	59.6
16585	Shoulders	7,971.0	....	....	3,520.0	3,486.6	608.2	50.8	86.9	745.9	7.97	43.8
16587	Feet	200.1	....	....	108.4	52.4	20.4	4.4	5.8	30.6	(0.64)	1.5
16589	Spareribs	1,195.4	....	....	646.6	321.6	168.1	9.7	18.3	196.1	1.43	12.4
16591	Tenderloins	348.5	....	....	231.9	39.8	63.8	1.3	3.8	68.9	1.22	4.0
16592	Neck bones	488.5	....	....	256.4	148.1	61.1	3.7	6.8	71.6	0.98	4.6
16594	Backbones	702.3	....	....	342.5	206.5	115.1	5.7	11.6	132.4	2.88	8.6
16596	Trimmings	8,155.7	....	....	1,637.7	6,046.0	265.1	35.9	70.9	371.9	6.52	24.5
16608	Tail	596.6	....	....	68.9	504.9	11.9	1.9	3.7	17.5	0.42	1.2
	Total for meats	....	54,952.5	88.03	17,483.5	32,464.4	3,191.3	338.0	492.1	4,021.4	48.14	251.5
16600	Bones (less marrow)	....	3,697.3	5.92	1,347.7	476.6	744.3	20.7	41.4	806.4	18.49	985.7
16601	Marrow	....	67.2	0.11	8.9	54.4	1.9	0.1	0.1	2.1	*a*0.12	....
16603	Skin	....	3,590.2	5.75	1,274.2	1,370.1	132.5	408.6	177.0	718.1	3.23	17.2
16605	Spinal cord	....	25.7	0.04	15.3	6.1	2.2	0.24	0.12	2.56	*a*0.38	*b*0.1
16607	Tendons	....	59.6	0.10	*b*35.2	*b*6.7	*b*14.3	*b*2.6	*b*0.6	*b*17.5	*b*0.11	*b*0.6
17181	Hoofs	....	31.0	0.05	11.1	0.2	....	....	....	20.4	....	0.3
	Total weights	....	62,424.1	....	20,165.0	34,378.5	4,086.5	772.4	712.4	5,611.5	70.47	1,255.4
	Total per cents of original material	....	....	100.00	32.32	55.07	6.55	1.24	1.14	8.99	0.11	2.01

PIG No. 6.—DUROC JERSEY.

	Meat (fat and lean):											
16725	Backs	19,194.9	....	....	3,900.4	14,133.2	720.0	84.5	138.2	942.7	38.39	55.7
16727	Bellies	14,101.6	....	....	4,867.9	8,315.9	617.7	79.0	83.2	779.9	16.92	31.0
16729	Hams	11,120.6	....	....	4,144.5	4,348.8	1,933.0	139.0	188.0	2,260.0	38.92	146.8
16731	Shoulders	9,171.7	....	....	3,619.2	4,511.0	687.9	86.2	97.2	871.3	11.01	77.0
16733	Feet	493.7	....	....	256.0	145.5	52.2	14.2	11.4	77.8	1.73	8.7

16735	Spareribs	1,214.3			605.2	388.0	165.5	13.7	13.2	192.4	4.01	13.4
16737	Tenderloins	421.3			269.1	62.4	72.9	2.7	3.7	79.3	2.86	4.4
16738	Neck bones	635.6			313.4	222.0	74.3	6.0	6.7	87.0	1.78	5.5
16740	Backbones	809.7			384.9	291.2	103.7	8.6	9.3	121.6	2.91	7.5
16742	Trimmings	10,679.6			1,763.1	8,413.4	326.8	40.6	53.4	420.8	7.48	26.7
16744	Tail	1,070.7			149.3	869.7	32.1	4.7	4.4	41.2	0.64	2.5
	Total for meats		68,913.7	90.92	20,273.0	41,701.1	4,786.1	479.2	608.7	5,874.0	126.15	374.2
16748	Bones (less marrow)		3,564.7	4.70	1,204.2	628.8	630.6	35.7	43.5	709.8	(12.05)	928.9
16751	Marrow		79.0	0.10	[b] 11.5	[b] 64.1	[b] 1.6	[b] 0.1	[b] 0.05	[b] 1.75	[a] 0.15	
16746	Skin		3,035.3	4.01	1,372.0	625.0	409.8	182.1	184.6	776.5	1.82	19.1
16749	Spinal cord		55.0	0.07	[b] 26.6	[b] 22.7	[b] 3.1	[b] 0.5	[b] 0.2	[b] 3.8	[c] 1.38	[b] 0.2
16753	Tendons		92.5	0.12	55.2	8.6	23.4	4.3	1.2	28.9	0.07	0.9
17182	Hoofs		59.2	0.08	26.4	0.4				31.7		0.6
	Total weights		75,799.4		22,968.9	43,050.7	5,854.6	701.9	838.25	7,426.45	141.62	1,323.9
	Total per cents of original material			100.00	30.31	56.81	7.73	0.93	1.11	9.80	0.19	1.75

PIG No. 7.—DUROC JERSEY.

	Meat (fat and lean):											
16754	Backs	16,807.7			3,400.3	12,429.3	682.4	94.1	84.0	860.5	80.68	48.8
16756	Bellies	12,404.8			2,670.9	9,125.0	348.6	47.1	38.5	434.2	59.54	26.1
16758	Hams	9,746 2			4,313.7	4,227.9	931.8	84.8	78.9	1,095.5	43.86	63.4
16760	Shoulders	8,043.4			3,589.0	3,430.2	728.7	75.6	70.0	874.3	49.87	73.2
16762	Feet	290.8			62.8	73.4	36.0	7.7	4.5	48.2	1.05	2.3
16764	Spareribs	1,114.1			592.7	306.5	162.2	12.6	12.2	187.0	9.25	11.3
16766	Tenderloins	333.3			242.8	31.2	49.0	1.7	1.9	52.6	1.07	2.0
16767	Neck bones	611.4			318.5	189.1	75.7	6.9	3.8	86.4	3.36	5.8
16769	Backbones	785.8			417.2	220.6	109.1	8.3	9.4	126.8	3.46	8.0
16771	Trimmings	10,029.2			2,055.0	7,377.1	339.0	63.2	75.2	477.4	11.03	28.1
16773	Tail	672.8			92.4	549.9	18.9	3.4	3.0	25.3	3.23	1.8
	Total for meats		60,839.5	90.16	17,755.3	37,960.2	3,481.4	405.4	381.4	4,268.2	266.40	271.7
16775	Bones (less marrow)		3,426.0	4.93	1,255.3	469.4	648.9	19.2	39.4	707.5	14.73	927.4
16776	Marrow		76.1	0.11	[b] 11.1	[b] 61.7	[b] 1.6	[b] 0.1	[b] 0.05	[b] 1.75	[a] 0.15	
16778	Skin		3,149.8	4.53	1,587.2	496.1	604.4	319.1	105.2	1,028.7	4.72	24.6
16780	Spinal cord		56.2	0.08	11.7	37.8	3.4	0.6	0.2	4.2	0.39	[b] 0.2
16782	Tendons		78.0	0.11	45.2	10.9	17.9	3.1	0.8	21.8	0.09	0.7
17183	Hoofs		52.0	0.08	22.9	0.3				29.0		0.5
	Total weights		67,677.6		20,688.7	39,036.4	4,757.6	747.5	527.05	6,061.15	286.48	1,225.1
	Total per cents of original material			100.00	30.58	57.68	7.03	1.10	0.78	8.96	0.42	1.81

[a] In fat extract, calculated from averages for like cuts.

[b] Calculated from averages of like cuts.

[c] In residue and fat extract.

TABLE No. 7.—*Data for the entire dressed animal; the head, leaf lard, and kidneys having been removed*—Continued.

PIG No. 8.—YORKSHIRE.

Serial No.	Names of parts.	Weight of parts—			Weight of each constituent.							
		From each cut.	Total.	Of entire pig.	Water.	Fat.	Nitrogenous substances.				Lecithin.	Ash.
							Proteids, insoluble in hot water.	Gelatinoids.	Flesh bases.	Total.		
	Meat (fat and lean):	*Grams.*	*Grams.*	*Per cent.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
16783	Backs	18, 458. 1	....	....	5, 269. 6	11, 541. 9	1, 096. 3	195. 7	114. 4	1, 406. 4	57. 22	75. 7
16785	Bellies	9, 562. 2	....	....	3, 231. 0	5, 376. 0	645. 4	119. 5	63. 1	828. 0	23. 91	45. 9
16787	Hams	10, 682. 4	....	....	6, 317. 6	2, 695. 0	1, 228. 4	92. 9	116. 5	1, 437. 8	44. 87	79. 0
16789	Shoulders	11, 124. 8	....	....	5, 514. 6	4, 015. 1	945. 6	96. 8	121. 3	1, 163. 7	18. 91	70. 1
16791	Feet	673. 3	....	....	387. 0	207. 8	34. 5	11. 0	10. 3	55. 8	0. 54	2. 8
16793	Spareribs	1, 774. 0	....	....	928. 0	519. 4	240. 6	20. 1	23. 8	284. 5	5. 85	18. 6
16795	Tenderloins	632. 5	....	....	421. 6	82. 7	101. 2	5. 1	6. 5	112. 8	4. 30	6. 6
16796	Neck bones	770. 9	....	....	425. 0	205. 9	102. 6	7. 7	8. 9	119. 2	4. 16	7. 6
16798	Backbones	1, 100. 0	....	....	557. 2	325. 8	155. 4	13. 8	14. 1	183. 3	8. 58	13. 0
16800	Trimmings	7, 743. 6	....	....	2, 022. 6	5, 096. 0	353. 1	77. 4	72. 8	503. 3	34. 07	30. 2
16802	Tail	565. 5	....	....	104. 6	420. 6	27. 6	6. 0	2. 3	35. 9	3. 11	1. 9
	Total for meats	....	63, 087. 3	86. 78	25, 178. 8	30, 486. 2	4, 930. 7	646. 0	554. 0	6, 130. 7	205. 52	351. 4
16804	Bones (less marrow)	....	5, 394. 0	7. 42	2, 232. 5	759. 5	988. 1	46. 9	50. 7	1, 085. 7	10. 79	1, 364. 7
16805	Marrow	....	92. 9	0. 13	13. 3	75. 8	1. 8	0. 17	0. 03	2. 0	0 06	....
16807	Skin	....	3, 857. 0	5. 30	*a*1,787. 0	*a* 882. 5	*a* 504. 9	*a* 334. 4	*a* 177. 0	*a*1,016. 3	*a* 7. 33	*a* 23. 9
16809	Spinal cord	....	66. 0	0. 09	*a* 31. 9	*a* 27. 2	*a* 3. 7	*a* 0. 6	*a* 0. 2	*a* 4. 5	*b* 0. 05	*a* 0. 3
16811	Tendons	....	133. 5	0. 18	*a* 78. 8	*a* 14. 9	*a* 32. 0	*a* 5. 8	*a* 1. 5	*a* 39. 3	*a* 0. 25	*a* 1. 4
17184	Hoofs	....	75. 0	0. 10	39. 2	0. 4	....	....	....	35. 1	....	0. 5
	Total weights	....	72, 705. 7	....	29, 361. 5	32, 246. 5	6, 461. 2	1, 033. 87	783. 43	8, 313. 6	224. 00	1, 742. 2
	Total per cents of original material	....	....	100. 00	40. 30	44. 35	8. 89	1. 42	1. 08	11. 44	0. 31	2. 40

a Calculated from averages of like cuts.

b In residue and fat extract.

TABLE 8 A.—*Chemical composition of the meat of the pigs, by cuts.*

AMERICAN CLEAR BACKS.

[Data are stated in percentages of the original material.]

Serial No.	Pig, number and variety.	Water.	Fat.	Nitrogenous substances.				Lecithin. *a*	Ash.	Total.
				Proteids insoluble in hot water.	Gelatinoids.	Flesh bases.	Total.			
16667	1. Berkshire	32.27	57.69	7.00	0.50	0.91	8.41	0.15	0.51	99.03
16696	2. Tamworth	29.13	61.76	5.75	0.69	0.91	7.35	0.13	0.43	98.80
16609	3. Chester White	23.72	70.16	4.50	0.44	0.75	5.69	0.12	0.35	100.04
16638	4. Poland China	26.13	66.33	5.13	0.56	0.81	6.50	*b* 0.21	0.38	99.55
16579	5. Duroc Jersey	20.75	73.25	3.94	0.50	0.84	5.28	0.08	0.29	99.65
16725	6. Duroc Jersey	20.32	73.63	3.75	0.44	0.72	4.91	*c* 0.20	0.29	99.35
16754	7. Duroc Jersey	20.23	73.95	4.06	0.56	0.50	5.12	*c* 0.48	0.29	100.07
16783	8. Yorkshire	28.55	62.53	5.94	1.06	0.62	7.62	*c* 0.32	0.41	99.43
	Means	25.14	67.41	5.01	0.59	0.76	6.36	0.21	0.37	99.49
	Maxima	32.27	73.95	7.00	1.06	0.91	8.41	0.48	0.51	100.07
	Minima	20.23	57.69	3.75	0.44	0.50	4.91	0.08	0.29	98.80

TABLE 8 B.—*Chemical composition of the meat of the pigs, by cuts.*

AMERICAN CLEAR BELLIES.

[Data are stated in percentages of the original material.]

Serial No.	Pig, number and variety.	Water.	Fat.	Nitrogenous substances.				Lecithin. *a*	Ash.	Total.
				Proteids insoluble in hot water.	Gelatinoids.	Flesh bases.	Total.			
16669	1. Berkshire	37.27	51.93	7.00	0.56	1.22	8.78	0.14	0.55	98.67
16698	2. Tamworth	33.69	56.52	7.00	0.63	0.91	8.54	0.15	0.47	99.37
16611	3. Chester White	30.54	60.73	5.44	0.63	1.03	7.10	0.08	0.42	98.87
16640	4. Poland China	30.78	60.69	4.81	0.63	1.19	6.63	0.12	0.43	98.65
16581	5. Duroc Jersey	29.13	62.83	5.06	0.56	1.00	6.62	0.10	0.42	99.10
16727	6. Duroc Jersey	34.52	58.97	4.38	0.56	0.59	5.53	*c* 0.12	0.22	99.36
16756	7. Duroc Jersey	21.53	73.56	2.81	0.38	0.21	3.50	*c* 0.48	0.21	99.28
16785	8. Yorkshire	33.79	56.22	6.75	1.25	0.66	8.66	*c* 0.25	0.48	99.40
	Means	31.41	60.18	5.41	0.65	0.86	6.92	0.18	0.48	99.09
	Maxima	37.27	73.56	7.00	1.25	1.22	8.78	*c* 0.48	0.55	99.40
	Minima	21.53	51.93	2.81	0.38	0.31	3.50	0.08	0.21	98.65

TABLE 8 C.—*Chemical composition of the meat of the pigs, by cuts.*

SHORT CUT HAMS.

[Data are stated in percentages of the original material.]

Serial No.	Pig, number and variety.	Water.	Fat.	Nitrogenous substances.				Lecithin. *a*	Ash.	Total.
				Proteids insoluble in hot water.	Gelatinoids.	Flesh bases.	Total.			
16671	1. Berkshire	60.29	22.19	14.00	0.69	1.15	15.84	*c* 0.65	0.96	99.93
16700	2. Tamworth	57.93	24.45	13.00	0.63	1.25	14.88	0.22	0.84	98.32
16613	3. Chester White	53.15	30.99	11.13	0.63	1.97	13.73	0.35	0.80	99.02
16642	4. Poland China	54.78	30.12	10.69	0.81	1.28	12.78	0.23	0.76	98.67
16583	5. Duroc Jersey	50.45	35.94	8.38	1.00	0.50	9.88	0.03	0.71	97.01
16729	6. Duroc Jersey	37.26	39.10	17.38	1.25	1.69	20.32	0.35	1.32	98.35
16758	7. Duroc Jersey	44.26	43.38	9.56	0.87	0.81	11.24	*c* 0.45	0.65	99.98
16787	8. Yorkshire	59.14	25.23	11.50	0.87	1.09	13.46	*c* 0.42	0.74	98.99
	Means	52.16	30.18	11.96	0.84	1.22	14.02	0.34	0.85	98.79
	Maxima	60.29	43.38	17.38	1.25	1.97	20.32	*c* 0.65	1.32	99.98
	Minima	37.26	22.19	8.38	0.63	0.81	9.88	0.03	0.65	97.01

a In extracted sample. *b* Calculated from averages of like cuts. *c* In residue and fat extract.

TABLE 8 D.—*Chemical composition of the meat of the pigs, by cuts.*

NEW YORK SHOULDERS.

[Data are stated in percentages of the original material.]

Serial No.	Pig, number and variety.	Water.	Fat.	Nitrogenous substances.				Lecithin. *a*	Ash.	Total.
				Proteids insoluble in hot water.	Gelatinoids.	Flesh bases.	Total.			
16673	1. Berkshire	54.97	29.01	11.25	0.81	1.56	13.62	0.15	0.89	98.64
16702	2. Tamworth	55.07	29.98	11.25	0.87	1.19	13.31	0.24	0.79	99.39
16615	3. Chester White	49.16	37.62	9.44	0.87	1.34	11.65	0.28	0.71	99.42
16644	4. Poland China	51.72	33.74	7.81	0.63	0.94	9.38	0.30	0.59	95.73
16585	5. Duroc Jersey	44.16	43.74	7.63	0.63	1.09	9.35	0.10	0.55	97.90
16731	6. Duroc Jersey	39.46	49.18	7.50	0.94	1.06	9.50	0.12	0.84	99.10
16760	7 Duroc Jersey	44 62	42.65	9.06	0.94	0.87	10.87	*b* 0.62	0.91	99.67
16789	8. Yorkshire	49.57	36.09	8.50	0.87	1.09	10.46	0.17	0.63	96.92
	Means	48.59	37.75	9.06	0.82	1.14	11.02	0.25	0.74	98.35
	Maxima	55.07	49.18	11.25	0.94	1.56	13.62	*b* 0.62	0.91	99.67
	Minima	39.46	29.01	7.50	0.63	0.87	9.35	0.10	0.55	95.73

TABLE 8 E.—*Chemical composition of the meat of the pigs, by cuts.*

FEET.

[Data are stated in percentages of the original material.]

Serial No.	Pig, number and variety.	Water.	Fat.	Nitrogenous substances.				Lecithin. *a*	Ash.	Total.
				Proteids insoluble in hot water.	Gelatinoids.	Flesh bases.	Total.			
16675	1. Berkshire	61.28	16.83	12.19	4.69	2.34	19.22	*b* 0.61	0.82	98.76
16704	2. Tamworth	58.66	21.23	11.63	3.38	2.96	17.97	*b* 0.51	0.86	99.23
16617	3. Chester White	53.05	26.74	9.88	6.38	1.06	17.32	0.19	0.84	98.04
16646	4. Poland China	50.66	31.32	11.00	4.19	0.97	16.16	0.15	0.91	99.20
16587	5. Duroc Jersey	54.16	26.19	10.19	2.19	2.90	15.28	*c* 0.32	0.76	96.71
16733	6. Duroc Jersey	51.84	29.47	10.56	2.88	2.31	15.75	*b* 0.35	0.75	98.16
16762	7. Duroc Jersey	55.98	25.25	12.38	2.63	1.53	16.54	*b* 0.36	0.78	98.91
16791	8. Yorkshire	57.47	30.86	5.13	1.63	1.53	8.29	0.08	0.41	97.11
	Means	55.39	25.99	10.37	3.50	1.95	15.82	0.32	0.77	98.28
	Maxima	61.28	31.32	12.38	6.38	2.96	19.22	*b* 0.61	0.91	99.23
	Minima	50.66	16.83	5.13	1.63	0.97	8.29	0.08	0.41	96.71

TABLE 8 F.—*Chemical composition of the meat of the pigs, by cuts.*

SPARERIBS.

[Data are stated in percentages of the original material.]

Serial No.	Pig, number and variety.	Water.	Fat.	Nitrogenous substances.				Lecithin. *a*	Ash.	Total.
				Proteids insoluble in hot water.	Gelatinoids.	Flesh bases.	Total.			
16677	1. Berkshire	52.54	29.10	13.44	1.13	1.19	15.76	0.35	1.00	98.75
16706	2. Tamworth	49.20	33.88	11.56	1.31	1.40	14.27	0.25	0.93	98.53
16619	3. Chester White	53.23	27.93	13.63	0.87	1.65	16.15	0.28	0.92	98.51
16648	4. Poland China	52.95	29.55	10.06	0.63	3.09	13.78	0.31	0.95	97.54
16589	5. Duroc Jersey	54.09	26.90	14.06	0.81	1.53	16.40	0.12	1.04	98.55
16735	6. Duroc Jersey	49.84	31.95	13.63	1.13	1.09	15.85	0.33	1.10	99.07
16764	7. Duroc Jersey	53.20	27.51	14.56	1.13	1.09	16.78	*b* 0.83	1.01	99.33
16793	8. Yorkshire	52.31	29.28	13.56	1.13	1.34	16.03	0.33	1.05	99.00
	Means	52.17	29.51	13.06	1.02	1.55	15.63	0.35	1.00	98.66
	Maxima	54.09	33.88	14.56	1.31	3.09	16.78	*b* 0.83	1.10	99.33
	Minima	49.20	26.90	10.06	0.63	1.00	13.78	0.12	0.92	97.54

a In extracted sample. *b* In residue and fat extract. *c* Calculated from averages of like cuts.

TABLE 8 G.—*Chemical composition of the meat of the pigs, by cuts.*

TENDERLOINS.

[Data are stated in percentages of the original material.]

Serial No.	Pig, number and variety.	Water.	Fat.	Nitrogenous substances.				Lecithin. *a*	Ash.	Total.
				Proteids insoluble in hot water.	Gelatinoids.	Flesh bases.	Total.			
16679	1. Berkshire	68.06	8.78	18.56	0.50	1.06	20.12	0.49	1.17	98.62
16708	2. Tamworth	65.52	13.51	17.13	0.56	0.91	18.60	*b* 0.91	1.06	99.60
16621	3. Chester White	65.97	13.47	16.69	0.44	1.03	18.16	0.40	1.06	99.06
16650	4. Poland China	67.43	10.95	17.63	0.69	0.78	19.10	0.39	1.13	99.00
16591	5. Duroc Jersey	66.55	11.41	18.31	0.38	1.09	19.78	0.35	1.14	99.23
16737	6. Duroc Jersey	63.86	14.81	17.31	0.63	0.87	18.81	0.56	1.05	99.09
16766	7. Duroc Jersey	72.83	9.35	14.69	0.50	0.56	15.75	0.32	0.86	99.11
16795	8. Yorkshire	66.65	13.07	16.00	0.81	1.03	17.84	*b* 0.68	1.04	99.28
	Means	67.11	11.92	17.04	0.56	0.92	18.52	0.51	1.06	99.12
	Maxima	72.83	14.81	18.56	0.81	1.09	20.12	*b* 0.91	1.17	99.60
	Minima	63.86	8.78	14.69	0.44	0.56	15.75	0.32	0.86	98.62

TABLE 8 H.—*Chemical composition of the meat of the pigs, by cuts.*

NECK BONES.

[Data are stated in percentages of the original material.]

Serial No.	Pig, number and variety.	Water.	Fat.	Nitrogenous substances.				Lecithin. *a*	Ash.	Total.
				Proteids insoluble in hot water.	Gelatinoids.	Flesh bases.	Total.			
16680	1. Berkshire	55.70	27.92	12.44	0.75	1.06	14.25	*b* 0.68	0.81	99.36
16709	2. Tamworth	55.52	26.03	13.38	1.31	1.40	16.09	*b* 0.83	1.02	99.49
16622	3. Chester White	53.50	29.52	12.19	0.75	1.31	14.25	0.25	0.87	98.39
16651	4. Poland China	55.23	28.27	10.25	1.13	1.75	13.13	*b* 0.45	0.91	97.99
16592	5. Duroc Jersey	52.48	30.31	12.50	0.75	1.40	14.65	0.20	0.94	98.58
16738	6. Duroc Jersey	49.30	34.92	11.69	0.94	1.06	13.69	0.28	0.87	99.06
16767	7. Duroc Jersey	52.10	30.92	12.38	1.13	0.62	14.13	*b* 0.55	0.94	98.64
16796	8. Yorkshire	55.13	26.71	13.31	1.00	1.15	15.46	*b* 0.54	0.90	98.83
	Means	53.62	29.33	12.27	0.97	1.22	14.46	0.47	0.92	98.79
	Maxima	55.70	34.92	13.38	1.31	1.75	16.09	*b* 0.83	1.02	99.49
	Minima	49.30	26.03	10.25	0.75	0.62	13.13	0.20	0.81	97.99

TABLE 8 I.—*Chemical composition of the meat of the pigs, by cuts.*

BACKBONES.

[Data are stated in percentages of the original material.]

Serial No.	Pig, number and variety.	Water.	Fat.	Nitrogenous substances.				Lecithin. *a*	Ash.	Total.
				Proteids insoluble in hot water.	Gelatinoids.	Flesh bases.	Total.			
16682	1. Berkshire	52.83	27.22	14.38	0.87	1.44	16.69	0.26	1.24	98.24
16711	2. Tamworth	51.06	30.67	13.69	0.87	1.22	15.78	0.25	1.10	98.86
16624	3. Chester White	50.39	31.65	13.38	0.56	1.34	15.28	0.23	1.05	98.60
16653	4. Poland China	51.26	30.98	12.94	0.81	1.34	15.09	0.27	1.05	98.65
16594	5. Duroc Jersey	48.77	29.40	16.38	0.81	1.65	18.84	0.41	1.23	98.65
16740	6. Duroc Jersey	47.54	35.96	12.81	1.06	1.15	15.02	0.36	0.92	99.80
16769	7. Duroc Jersey	53.09	28.07	13.88	1.06	1.19	16.13	*b* 0.44	1.02	98.75
16798	8. Yorkshire	50.65	29.61	14.13	1.25	1.28	16.66	*b* 0.78	1.18	98.88
	Means	50.70	30.45	13.95	0.91	1.33	16.19	0.38	1.10	98.81
	Maxima	53.09	35.96	16.38	1.25	1.65	18.84	*b* 0.78	1.24	99.80
	Minima	47.54	27.22	12.81	0.56	1.15	15.02	0.23	0.92	98.24

a In extracted sample.

b In residue and fat extract.

TABLE 8 J.—*Chemical composition of the meat of the pigs, by cuts.*

TRIMMINGS.

[Data are stated in percentages of the original material.]

Serial No.	Pig, number and variety.	Water.	Fat.	Nitrogenous substances.				Lecithin. *a*	Ash.	Total.
				Proteids insoluble in hot water.	Gelatinoids.	Flesh bases.	Total.			
16684	1. Berkshire	29.68	62.00	5.19	0.69	1.03	6.91	0.11	0.41	99.11
16713	2. Tamworth	28.85	62.67	5.31	0.81	1.03	7.15	0.10	0.43	99.20
16626	3. Chester White	22.49	71.55?	3.25	0.50	0.84	4.59	0.07	0.31	99.01
16655	4. Poland China	22.43	71.52	3.69	0.44	0.69	4.82	0.06	0.32	99.15
16596	5. Duroc Jersey	20.08	74.13	3.25	0.44	0.87	4.56	0.08	0.30	99.15
16742	6. Duroc Jersey	16.51	78.78	3.06	0.38	0.50	3.94	0.07	0.25	99.54
16771	7. Duroc Jersey	20.49	73.56	3.38	0.63	0.75	4.76	*b* 0.11	0.28	99.20
16800	8. Yorkshire	26.12	65.81	4.56	1.00	0.94	6.50	*b* 0.44	0.39	99.26
	Means	23.33	70.00	3.96	0.61	0.83	5.40	0.13	0.34	99.20
	Maxima	29.68	78.78	5.31	1.00	1.03	7.15	*b* 0.44	0.43	99.54
	Minima	16.51	62.00	3.06	0.38	0.50	3.94	0.06	0.25	99.01

TABLE 8 K.—*Chemical composition of the meat of the pigs, by cuts.*

TAIL.

[Data are stated in percentages of the original material.]

Serial No.	Pig, number and variety.	Water.	Fat.	Nitrogenous substances.				Lecithin. *a*	Ash.	Total.
				Proteids insoluble in hot water.	Gelatinoids.	Flesh bases.	Total.			
16686	1. Berkshire	24.02	68.23	5.75	0.56	0.50	6.81	0.17	0.39	99.62
16715	2. Tamworth	25.77	67.08	4.25	0.69	0.78	5.72	0.10	0.30	98.97
16628	3. Chester White	15.66	79.69	3.00	0.44	0.62	4.06	0.08	0.24	99.73
16657	4. Poland China	16.50	77.77	3.44	0.56	0.66	4.66	0.09	0.31	99.33
16598	5. Duroc Jersey	11.54	84.62	2.00	0.31	0.62	2.93	0.07	0.20	99.36
16744	6. Duroc Jersey	13.94	81.23	3.00	0.44	0.41	3.85	0.06	0.23	99.31
16773	7. Duroc Jersey	13.73	81.74	2.81	0.50	0.44	3.75	*b* 0.48	0.27	99.97
16802	8. Yorkshire	18.50	74.37	4.88	1.06	0.41	6.35	*b* 0.55	0.33	100.10
	Means	17.46	76.84	3.64	0.57	0.56	4.77	0.20	0.28	99.55
	Maxima	25.77	84.62	5.75	1.06	0.78	6.81	*b* 0.55	0.39	100.10
	Minima	11 54	67.08	2.00	0.31	0.41	2.93	0.06	0.20	99.31

TABLE 9.—*Average composition of the meats from all the cuts of each animal.*

[Percentages.]

Number and name of pig.	Water.	Fat.	Nitrogenous substances.				Lecithin. *c*	Ash.	Total.
			Proteids insoluble in hot water.	Gelatinoids.	Flesh bases.	Total.			
1. Berkshire	43.12	43.98	9.21	0.67	1.15	11.03	0.25	0.68	99.06
2. Tamworth	40.60	47.22	8.52	0.76	1.07	10.35	0.17	0.60	98.94
3. Chester White	35.13	54.83	6.84	0.63	1.13	8.60	0.18	0.52	99.26
4. Poland China	37.17	52.27	6.65	0.65	1.03	8.33	0.16	0.52	98.45
5. Duroc Jersey	31.82	59.08	5.81	0.62	0.89	7.32	0.09	0.46	98.67
6. Duroc Jersey	29.42	60.53	6.95	0.70	0.88	8.53	0.18	0.54	99.20
7. Duroc Jersey	29.63	61.83	5.82	0.67	0.64	7.13	0.44	0.46	99.49
8. Yorkshire	39.91	48.32	7.82	1.02	0.88	9.72	0.33	0.56	98.84
Means	35.85	53.51	7.20	0.72	0.96	8.88	0.23	0.54	98.99
Maxima	43.12	61.83	9.21	1.02	1.15	11.03	0.44	0.68	99.26
Minima	29.42	43.98	5.81	0.62	0.64	7.13	0.09	0.46	98.45

a In extracted sample. *b* In residue and fat extract.
c In the residue after the removal of the fat.

Table 10.—*Averages computed from all the bones of each cut of each animal, without marrow.*

[Percentages.]

Number and name of pig.	Water.	Fat.	Nitrogenous substances.				Lecithin. *a*	Ash.	Total.
			Proteids insoluble in hot water.	Gelatinoids.	Flesh bases.	Total.			
1. Berkshire	38.94	11.67	17.50	0.38	1.25	19.13	0.44	26.12	96.30
2. Tamworth	38.06	15.06	17.56	0.69	0.81	19.06	0.04	25.35	97.57
3. Chester White	40.41	17.18	17.57	0.50	1.03	19.10	0.06	21.69	98.44
4. Poland China	42.70	9.87	16.51	1.75	1.56	19.82	0.53	25.25	98.17
5. Duroc Jersey	36.45	12.89	20.13	0.56	1.12	21.81	0.50	26.66	98.31
6. Duroc Jersey	33.78	17.64	17.69	1.00	1.22	19.91	*b* 0.31	26.06	97.70
7. Duroc Jersey	36.64	13.70	18.94	0.56	1.15	20.65	*c* 0.43	27.07	98.49
8. Yorkshire	41.39	14.08	18.32	0.87	0.94	20.13	0.20	25.30	101.10
Means	38.55	14.01	18.03	0.79	1.14	19.95	0.31	25.44	98.26
Maxima	42.70	17.64	20.13	1.75	1.56	21.81	0.53	27.07	101.10
Minima	33.78	9.87	16.51	0.38	0.81	19.06	0.04	21.69	96.30

a In the residue after the removal of the fat.
b Calculated from averages of like cuts.
c In residue and fat extract.

Table 11.—*Analytical data for marrow.*

[Percentages.]

Number and name of pig.	Water.	Fat.	Nitrogenous substances.				Lecithin. *a*	Ash.	Total.
			Proteids insoluble in hot water.	Gelatinoids.	Flesh bases.	Total.			
1. Berkshire	14.36	81.51	2.00	0.19	0.06	2.25	0.46	....	98.58
2. Tamworth	13.31	84.48	1.38	0.06	0.06	1.50	0.05	....	99.34
3. Chester White	15.50	79.86	1.88	0.06	0.06	2.00	(0.06)	....	97.42
4. Poland China	16.74	78.35	2.56	0.13	0.03	2.72	(0.06)	....	97.87
5. Duroc Jersey	13.22	80.97	2.88	0.19	0.09	3.16	(0.06)	....	97.41
8. Yorkshire	14.29	81.58	1.88	0.19	0.03	2.10	0.06	....	98.03
Means	14.57	81.13	2.10	0.14	0.06	2.29	0.13	....	98.11
Maxima	16.74	84.48	2.88	0.19	0.09	3.16	0.46	....	99.34
Minima	13.22	78.35	1.38	0.06	0.03	1.50	0.05	....	97.41

a In the residue after removal of the fat.

Table 12.—*Analytical data for skin.*

[Percentages.]

Number and name of pig.	Water.	Fat.	Nitrogenous substances.				Lecithin. *a*	Ash.	Total.
			Proteids insoluble in hot water.	Gelatinoids.	Flesh bases.	Total.			
1. Berkshire	50.24	17.11	25.25	6.69	1.37	33.31	*b* 0.41	0.63	101.70
2. Tamworth	55.38	14.15	16.62	9.00	3.12	28.74	*b* 0.25	0.65	99.17
3. Chester White	40.78	31.17	4.50	6.06	7.89	18.45	0.10	0.53	91.03
4. Poland China	46.81	23.31	8.87	11.44	5.37	25.68	0.25	0.63	96.68
5. Duroc Jersey	35.49	38.16	3.69	11.38	4.93	20.00	0.09	0.48	94.22
6. Duroc Jersey	45.20	20.59	13.50	6.00	6.08	25.58	0.06	0.63	92.06
7. Duroc Jersey	50.39	15.75	19.19	10.13	3.34	32.66	*b* 0.15	0.78	99.73
Means	46.33	22.89	13.09	8.67	4.59	26.35	0.19	0.62	96.52
Maxima	55.38	38.16	25.25	11.44	7.89	33.31	0.41	0.78	101.70
Minima	35.49	14.15	3.69	6.00	1.37	18.45	0.06	0.48	91.03

a In the residue, after removal of the fat. *b* In residue and fat extract.

TABLE 13.—*Analytical data for spinal cord.*

[Percentages.]

Number and name of pig.	Water.	Fat.	Nitrogenous substances.				Lecithin. *a*	Ash.	Total.
			Proteids insoluble in hot water.	Gelatinoids.	Flesh bases.	Total.			
1. Berkshire	65.70	26.76	3.88	0.69	0.16	4.73	*b* 1.47	....	98.66
2. Tamworth	46.45	45.39	4.06	0.63	0.34	5.03	*c* 2.95	0.23	100.05
4. Poland China	48.86	42.94	5.50	1.06	0.22	6.78	*c* 1.10	0.56	100.24
5. Duroc Jersey	59.50	23.62	8.56	0.94	0.47	9.97	*b* 1.47	....	94.56
7. Duroc Jersey	20.84	67.82	6.06	1.00	0.28	7.34	*c* 0.70	....	96.20
Means	48.27	41.21	5.61	0.86	0.29	6.77	*c* 1.54	0.39	97.94
Maxima	65.70	67.32	8.56	1.06	0.47	9.97	*c* 2.95	0.56	100.24
Minima	20.84	23.62	3.88	0.63	0.16	4.73	*c* 0.70	0.23	94.56

a In the residue after removal of the fat. *b* In fat extract calculated from averages of like cuts.
c In fat extract.

TABLE 14.—*Analytical data for tendons.*

[Percentages.]

Number and name of pig.	Water.	Fat.	Nitrogenous substances.				Lecithin. *a*	Ash.	Total.
			Proteids insoluble in hot water.	Gelatinoids.	Flesh bases.	Total.			
1. Berkshire	58.43	13.40	22.24	4.44	0.62	27.50	*b* 0.45	1.18	100.96
2 Tamworth	61.55	8.09	24.19	4.31	1.37	29.87	0.10	1.09	100.70
3. Chester White	60.12	10.41	24.25	3.25	1.31	28.81	0.28	0.85	100.47
4. Poland China	56.68	11.68	24.75	5.50	0.97	31.22	0.10	1.48	101.16
6. Duroc Jersey	59.62	9.32	25.25	4.63	1.31	31.19	0.08	0.96	101.17
7. Duroc Jersey	57.91	14.02	22.94	3.94	0.97	27.85	0.11	0.87	100.76
Means	59.05	11.15	23.97	4.35	1.10	29.41	0.19	1.07	100.87
Maxima	61.55	14.02	25.25	5.50	1.37	31.22	*b* 0.45	1.48	101.17
Minima	56.68	8.09	22.44	3.25	0.62	27.50	0.08	0.85	100.47

a In the residue after the removal of the fat. *b* In residue and fat extract.

TABLE 15.—*Analytical data for hoofs.*

[Percentages.]

Number and name of pig.	Water.	Fat.	Nitrogenous substances.				Ash.	Total.
			Proteids insoluble in hot water.	Gelatinoids.	Flesh bases.	Total.		
1. Berkshire	41.09	0.86	....	....	....	58.00	0.93	100.88
2. Tamworth	43.47	0.61	....	....	....	55.63	0.98	100.69
3. Chester White	39.31	0.70	....	....	....	60.25	0.89	101.15
4. Poland China	47.52	0.60	....	....	....	52.31	0.81	101.24
5. Duroc Jersey	35.10	0.74	....	....	....	64.63	0.85	101.32
6. Duroc Jersey	44.68	0.69	....	....	....	53.50	1.02	99.89
7. Duroc Jersey	47.12	....	....	....	....	55.69	....	....
8 Yorkshire	52 26	0.49	....	....	....	46.75	0.71	100.21
Means	43.82	0.67	....	....	....	55.85	0.88	100.77
Maxima	52.26	0.86	....	....	....	64.63	1.02	101.32
Minima	35.10	0.49	....	....	....	46.75	0.71	99.89

TABLE 16.—*Weights of the entire animals and their various cuts, as weighed in Chicago and in Washington, together with the apparent percentages of gain or loss in transit.*

Number and name of pig.	Two clear backs.		Two clear bellies.		Two short-cut hams.		Two New York shoulders.	
	Chicago.	Washington.	Chicago.	Washington.	Chicago.	Washington.	Chicago.	Washington.
1. Berkshire:								
Pounds	35½	34⅜	19½	19¼	23½	23 5/16	20½	20⅝
Grams	16,102.8	15,592.5	8,845.2	8,731.8	10,659.6	10,574.6	9,298.8	9,355.5
2. Tamworth:								
Pounds	41	40½	20	19 9/16	26	25¾	21	20¾
Grams	18,597.6	18,370.8	9,072.0	8,873.6	11,793.6	11,680.2	9,525.6	9,412.2
3. Chester White:								
Pounds	36	35¾	21	21	20	19 15/16	21	20 13/16
Grams	16,329.6	16,216.2	9,525.6	9,525.6	9,072.0	9,057.8	9,525.6	9,440.5
4. Poland China:								
Pounds	40	38¾	24	23⅝	26	25⅞	24	23 7/16
Grams	18,144.0	17,577.0	10,886.2	10,716.1	11,793.6	11,736.9	10,886.2	10,631.1
5. Duroc Jersey:								
Pounds	39½	39½	24	24⅛	21	21	19½	19 13/16
Grams	17,917.2	17,917.2	10,886.4	10,943.1	9,525.6	9,525.6	8,845.2	8,987.0
6. Duroc Jersey:								
Pounds	45	44½	32½	32 11/16	27	26⅞	22	22⅛
Grams	20,412.0	20,185.2	14,742.0	14,827.1	12,247.2	12,190.5	9,979.2	10,035.9
7. Duroc Jersey:								
Pounds	39½	38⅞	28½	29	23½	23 13/16	19½	19¾
Grams	17,917.2	17,633.7	12,927.6	13,154.4	10,659.6	10,801.4	8,845.2	8,958.6
8. Yorkshire:								
Pounds	44	43 13/16	22½	23 1/16	27	27¼	24½	25 5/16
Grams	19,958.4	19,873.4	10,206.0	10,461.2	12,247.2	12,360.6	11,113.2	12,502.4

Number and name of pig.	Four feet.		Spareribs.		Tenderloins.		Neck bones.	
	Chicago.	Washington.	Chicago.	Washington.	Chicago.	Washington.	Chicago.	Washington.
1. Berkshire:								
Pounds	3½	3⅓	5	4⅞	1	1 1/25	2	1⅞
Grams	1,594.2	1,514.1	2,268.0	2,212.0	453.6	470.8	907.2	842.5
2. Tamworth:								
Pounds	4½	4⅓	5	4 7/16	1	1⅙	2	1 9/16
Grams	2,057.3	1,974.1	2,268.0	2,132.7	453.6	528.2	907.2	886.0
3. Chester White:								
Pounds	2½	2 7/16	3	3 1/16	1	1	1½	1 9/16
Grams	1,152.5	1,236.9	1,360.8	1,409.0	453.6	453.6	680.4	683.7
4. Poland China:								
Pounds	3	2 15/16	5	4⅓	1	9/16	1½	1⅘
Grams	1,360.8	1,359.0	2,268.0	1,969.5	453.6	419.8	680.4	815.6
5. Duroc Jersey:								
Pounds	2½	2¾	3½	3⅝	1	¾	1½	1¾
Grams	1,137.9	1,255.4	1,587.6	1,612.0	453.6	348.5	680.4	784.0
6. Duroc Jersey:								
Pounds	3½	3⅜	4	3 9/16	½	9/16	2	1 9/16
Grams	1,587.6	1,547.2	1,814.4	1,612.2	226.8	421.3	907.2	892.6
7. Duroc Jersey:								
Pounds	2½	3 1/16	3½	3⅓	¾	¾	2	1 15/16
Grams	1,134.0	1,400.0	1,587.6	1,504.0	340.2	333.3	907.2	906.5
8. Yorkshire:								
Pounds	4½	4 15/16	5	5⅛	1	1⅖	2	2⅝
Grams	2,041.2	2,246.0	2,268.0	2,340.0	453.6	632.5	907.2	1,192.3

Number and name of pig.	Backbones.		Trimmings.		Tail.		Total.		Per cent of gain or loss in transit.
	Chicago.	Washington.	Chicago.	Washington.	Chicago.	Washington.	Chicago.	Washington.	
1. Berkshire:									
Pounds	3½	3 7/16	18	16 9/16	¼	⅘	132¼	129⅝	Loss.
Grams	1,587.6	1,580.0	8,164.8	7,512.8	113.4	363.0	59,995.2	58,789.6	2.01
2. Tamworth:									
Pounds	4	4 9/16	18¼	16⅝	¼	1 9/16	143	140 9/16	Loss.
Grams	1,814.4	1,840.0	8,278.2	7,541.1	113.4	707.5	64,880.9	63,946.4	1.44
3. Chester White:									
Pounds	2½	2 9/16	27	15¾	¼	1⅝	135¾	125⅞	Loss.
Grams	1,134.0	1,172.6	12,247.2	7,144.2	113.4	740.2	61,594.7	57,080.3	8.07

TABLE 16.—*Weights of the entire animals and their various cuts, etc.*—Continued.

Number and name of pig.	Backbones.		Trimmings.		Tail.		Total.		Per cent of gain or loss in transit.
	Chicago.	Washington.	Chicago.	Washington.	Chicago.	Washington.	Chicago.	Washington.	
4. Poland China:									
Pounds	3	2 9/10	21¼	20	¼	1 7/10	149	146⅓	Loss.
Grams	1,360.8	1,315.5	9,639.0	9,072.0	113.4	760.0	67,586.4	66,372.5	1.80
5. Duroc Jersey:									
Pounds	3	3⅙	20¼	19 11/16	¼	1 9/16	136	138 1/16	Gain.
Grams	1,360.8	1,438.0	9,185.4	8,930.3	113.4	683.0	61,693.5	62,424.1	1.18
6. Duroc Jersey:									
Pounds	3½	3⅖	27¼	25 1/16	¼	2⅗	167½	167 1/10	Loss.
Grams	1,587.6	1,546.0	12,360.6	11,368.4	113.4	1,173.0	75,978.0	75,799.4	0.27
7. Duroc Jersey:									
Pounds	3	3¼	24¾	23 11/16	¼	1 7/10	147¾	149⅕	Gain.
Grams	1,360.8	1,482.0	11,226.6	10,744.7	113.4	759.0	67,019.4	67,677.6	0.98
8. Yorkshire:									
Pounds	4	4⅖	24¾	18⅝	¼	1 7/16	159½	160 3/10	Gain.
Grams	1,814.4	1,998.0	11,226.6	8,448.3	113.4	651.0	72,349.2	72,705.7	0.49

TABLE 17.—*Relative proportions of parts of pigs, expressed in percentages, of the entire dressed animal, the head, leaf lard, and kidneys having been removed.*

Number and name of pig.	Weight in pounds (Washington).	Percentages of parts.							
		Meat (fat and lean).	Bones, less marrow	Marrow.	Skin.	Spinal cord.	Tendons.	Hoofs.	Total.
1. Berkshire	129.6	88.19	7.44	0.12	3.80	0.09	0.27	0.09	100
2. Tamworth	141	86.50	8.18	0.21	4.71	0.09	0.21	0.10	100
3. Chester White	125.8	87.94	6.21	0.08	5.52	0.07	0.12	0.06	100
4. Poland China	146.4	90.67	5.30	0.11	3.63	0.08	0.14	0.07	100
5. Duroc Jersey	137.6	88.03	5.92	0.11	5.75	0.04	0.10	0.05	100
6. Duroc Jersey	167.1	90.93	4.70	0.10	4.00	0.07	0.12	0.08	100
7. Duroc Jersey	149.2	89.90	5.07	0.11	4.65	0.08	0.11	0.08	100
8. Yorkshire	160.3	86.79	7.41	0.13	5.30	0.09	0.18	0.10	100
Means	144.6	88.62	6.28	0.12	4.67	0.08	0.16	0.08	100
Maxima	167.1	90.93	8.18	0.21	5.75	0.09	0.27	0.10	100
Minima	125.8	86.79	4.70	0.08	3.63	0.04	0.10	0.05	100

TABLE 18.—*Analytical data, expressed in percentages, of the entire dressed animal, the head, leaf lard, and kidneys having been removed.*

Number and name of pig.	Weight in pounds.	Water.	Fat.	Nitrogenous substances.				Lecithin.*a*	Ash.	Total.
				Proteids insoluble in hot water.	Gelatinoids.	Flesh bases.	Total.			
1. Berkshire	129⅗	43.10	40.46	10.45	0.89	1.16	13.02	0.27	2.57	99.42
2. Tamworth	141	41.09	42.07	9.65	1.15	1.14	11.99	0.17	2.63	98.85
3. Chester White	125⅘	35.80	51.11	7.39	0.92	1.50	9.85	0.17	1.84	98.77
4. Poland China	146⅖	37.83	48.90	7.27	1.11	1.21	9.66	0.19	1.83	98.41
5. Duroc Jersey	137⅗	32.32	55.07	6.55	1.24	1.14	8.90	0.11	2.01	98.50
6. Duroc Jersey	167 1/10	30.31	56.81	7.73	0.93	1.11	9.80	0.19	1.75	98.86
7. Duroc Jersey	149⅕	30.58	57.68	7.03	1.10	0.78	8.96	0.42	1.81	99.45
8. Yorkshire	160 3/10	40.39	44.35	8.89	1.42	1.08	11.44	0.31	2.40	98.89
Means	144⅗	36.43	49.67	8.12	1.10	1.14	10.46	0.23	2.11	98.90
Maxima	167 1/10	43.10	57.68	10.45	1.42	1.50	13.02	0.42	2.63	99.45
Minima	125⅘	30.31	40.46	6.55	0.89	0.78	8.96	0.11	1.81	98.41

a In extracted residue, except as noted in preceding tables.

DISCUSSION OF THE DATA.

Tables 1 to 6, inclusive, contain the original analytical data from which the subsequent data showing the details of the composition of the meat were computed. The character of the data in these tables is pretty fully explained in a previous part of this report. These tables are particularly valuable, because they are the records of the data as made at the time the observations were made, and therefore show the extent and nature of the analytical work more elaborately than would be indicated by the details of tabular data shown in subsequent tables, which were obtained from a careful analytical study of Tables 1 to 6. It is believed that with the explanation previously given the student will be able to understand thoroughly the nature of the tables mentioned.

In Table 7 are found the general data in parts by weight for all the different parts and cuts of each animal. The footings show the total weight, in grams, of each constituent of each animal, and the second horizontal column of footings shows the percentage by weight of each constituent for each animal. The data in Table 7 are calculated from the original data contained in Tables 1 to 6, inclusive. The captions of Table 7 will explain sufficiently the nature of the data.

COMPOSITION OF THE SAME CUTS FROM THE DIFFERENT ANIMALS.

Tables 8 A to 8 K, inclusive, contain a comparison of the composition of the meat of the same cuts of each animal. Each table in the caption designates the character of the cut of meat on which the comparison is made. For instance—

Clear backs.—Table 8 A is a comparison of the composition of the meat of the American clear backs of all the animals. A study of the data reveals quite a variation in the composition of the meat from the different animals, and this variation is found in all the series of data. As in the other cases, we find that there is a corresponding relationship between the water and fat, one varying inversely as the other, so that the sum of the two is almost a constant quantity. The extremes of variation in water are found in the Berkshire and Duroc Jersey, namely, 32.27 and 20.23 per cent, respectively. The extremes of fat are also found in the same animals, namely, 57.69 and 73.95, respectively. In nitrogenous substances, as would naturally be expected, there is a corresponding variation, the samples which have the most fat, as a rule, having a lower percentage of nitrogenous bodies, and vice versa. This rule is not of rigid application, but must be regarded only in a general sense. For instance, in Table 8 A the largest percentage of nitrogenous substance is found in the Berkshire, which also has the smallest percentage of fat, while the smallest percentage of nitrogenous matter is found in the Duroc Jersey, No. 6, which, with one slight exception, has also the largest quantity of fat. The distribution of the nitrogenous substances in the meats of the American clear backs is found in the table, where they are divided into three classes, namely, the true proteids, insoluble in hot water; gelatinoids, which are of a true proteid character, but soluble in hot water, and of which gelatin is the type; and the flesh bases, which are soluble in hot water and are not precipitated by the action of bromin. The ash, as would be expected in animal products, entirely free of bone, is not very large in quantity. It consists chiefly of common salt and the phosphates of the alkali metals. The sum of the substances obtained on analysis shows that very little of the whole matter was unaccounted for, and, when the nature of the material on which the work was done is considered, it is seen that the summation is eminently satisfactory.

Clear bellies.—In Table 8 B we find a study of the comparison of the meat of American clear bellies exactly analogous to that which has been described for the American clear backs. As a rule it will be seen that the percentage of water in the clear bellies is higher and the percentage of fat lower than in the American clear backs. The general remarks already made in regard to the clear backs may be applied to this table without tiresome repetition. The relations between the nitrogenous substances and the water and fat and the ash are practically the same as for those just described, while the summation of the analyses also shows a satisfactory accounting for the materials which the chemist is furnished. It will be noticed that the flesh bases in the clear bellies are higher than in the clear backs. Data of this kind are of a practical nature as well as of a scientific value, in indicating what portion of the carcasses of animals could best be used, for instance, for the manufacture of extracts. A similar study applied to beef cattle would reveal data of unusual interest in this respect. Again, we find the largest percentage of water in the case of the Berkshire, and also the smallest percentage of fat, while the smallest percentage of water and the largest percentage of fat are found in the Duroc Jersey, No. 7, this showing a remarkable concordance between the character of the meats of the two cuts in the various animals.

Short-cut hams.—Table 8 C contains a comparison of the data of the meat of short-cut hams. In this cut of meat is found a smaller percentage of fat, a correspondingly large percentage of water, and, of course, in the increase of the muscular tissue, a very largely increased amount of nitrogenous matters. Again, the largest quantity of water and the smallest quantity of fat are found in the meat of the Berkshire, while the smallest quantity of water is found in the Duroc Jersey, No. 6, and the largest quantity of fat in the Duroc Jersey, No. 7. The general relation of water and fat is thus found to be the same in this cut as in the two preceding ones. In regard to the nitrogenous substances there is quite a remarkable variation. The largest percentage of nitrogenous bodies is found in Duroc Jersey, No. 6, while the smallest is found in the Duroc Jersey, No. 5. It seems rather strange that two animals of the same breed show such a remarkable discrepancy in composition. In this instance, however, there is a deficit of material amounting to almost 3 per cent unaccounted for; so that the analytical data do not have the value which they would have did the summation reach more nearly 100. In the short-cut hams there is found a considerable increase in the quantity both of gelatinoid proteids and flesh bases over the amounts in the cuts already described.

New York shoulders.—Table 8 D contains comparisons of the meat of the cuts known as New York shoulders. In this cut we have a larger percentage of fat than in the one just described, and a correspondingly smaller quantity of water and a smaller quantity of nitrogenous bodies. The summation of the analyses is not as satisfactory as in most of the preceding cases, and in one case a deficit of 4¼ per cent is noticed. Working, however, with wet material, and in the manner which was made necessary in such an investigation, it is not to be wondered at that often discrepancies of this nature may occur. These discrepancies are probably due chiefly to the determinations of water and fat, which are the most difficult of all connected with the operation of determining the composition of fresh meats, and inasmuch as the water and fat constitute by far the largest portion of the material it is seen that these difficulties must now and then result in failing to secure in the summation an accounting for all the material present. The largest percentage of water in these cuts is found in the Tamworth, and the smallest percentage of fat in the Berkshire. The smallest percentage of water is found in Duroc Jersey, No. 6, and the largest percentage of fat in the same animal. The relation between the nitrogenous substances is sufficiently indicated in the table, and calls for no especial comment.

Feet.—Table 8 E contains a comparison of the composition of the meat of the feet of the different animals. In the feet we find a marked difference in the analytical data, and especially on account of the fact that the feet, as is well known, contain large quantities of gelatin, and, as the data show, also considerable quantities of flesh bases. The total quantities of nitrogenous matters, in proportion to the other materials, is much larger in the feet than in the preceding cuts, while the quantity of gelatin is shown with sufficient emphasis in the tables of analytical data. However, a remarkable variation from the type is found in the feet of the Yorkshire pig, where the total amount of nitrogenous matter is only about half of that of the other animals. The summation of this analysis shows approximately 100 per cent, and therefore the feet of this animal must be regarded as differing essentially from those of other pigs examined. In regard to the gelatin we find that the largest percentage is found in the feet of the Chester White, and the smallest in those of the Yorkshire. The largest quantity of nitrogenous matter is found in the feet of the Berkshire, and the smallest in the feet of the Yorkshire pig. Again, the Berkshire leads all the others in having a maximum quantity of water and a minimum quantity of fat in its feet. The smallest quantity of water was found in the feet of the Poland China, and the smallest quantity of fat in the feet of the Berkshire.

Spareribs.—Table 8 F contains a comparison of the composition of the meat of the spareribs. In this case the largest percentage of water was found in Duroc Jersey, No. 5, and the smallest in the Tamworth. The smallest quantity of fat was found in Duroc Jersey, No. 5, and the largest in the Tamworth. The spareribs are rich in nitrogenous matters, mostly of a proteid nature. The content of flesh bases in the Poland China is remarkably high, being nearly double that of the average. The summations of the analyses for this table are satisfactory.

Tenderloins.—Table 8 G contains a comparison of the tenderloins of the different animals. The maximum content of water in these cuts was found in Duroc Jersey, No. 7, and the minimum in Duroc Jersey, No. 6. The maximum content of fat is found in the Duroc Jersey, No. 6, and the minimum in the Berkshire. The tenderloins differ from all the preceding cuts in having a largely increased quantity of water and a decreased quantity of fat. On account of the muscular nature of the tissue the proportion of nitrogenous substances is larger than in any of the cuts preceding. These substances are mostly of a proteid nature, there being only a comparatively small quantity of gelatinoids and flesh bases. The ash of these meats is also quite high, showing a large content of mineral nutritive substances. The summations of the analyses are quite satisfactory.

Neck bones.—Table 8 H contains a comparison of the meat from the neck bones of the animal. These meats show quite a uniform composition, there being less variation among the different animals than in almost any of the cuts secured. For instance, the maximum content of water in these meats is 55.70 and the minimum 49.30, while the maximum content of fat is 34.92 and the minimum 26.03. There is also a quite uniform agreement in the content of nitrogenous substances as a whole and in each particular class, the variations being only nominal. The ash is also uniform in amount and the summation of the analyses satisfactory. The meat from the neck bones, therefore, shows the most uniform agreement in composition of different animals of any of the cuts yet studied.

Backbones.—Table 8 I contains a comparison of the composition of the meat from the backbones. There is also here a quite uniform agreement in the content of water and fat, the maximum content of water being 53.09 and the minimum 47.54, while in the case of the fat the maximum content is 35.96 and the minimum 27.22. The whole of the nitrogenous substances show also a greater uniformity, the only variation being in the case of Duroc Jersey, No. 5, where the total of the nitrogenous bodies is considerably higher than the mean of the other animals. Most of the nitrogenous matter in the meat of the backbones is protein, although the quantity of flesh bases is in every case more than 1 per cent. The ash is also quite high, showing a large proportion of nutritive mineral matters. The summation of the analyses is satisfactory.

Trimmings.—Table 8 J shows the composition of the trimmings from the different animals. These trimmings, as will be seen, consist chiefly of the fatty portions which are rejected in preparing the cuts for market. They are used principally for the manufacture of lard. They therefore show an excessively high content of fat and a comparatively low content of water and of nitrogenous bodies and ash. The summation of the analyses of these materials is therefore eminently satisfactory. The analytical data show that the trimmings from the different animals are quite uniform in composition.

Tails.—Table 8 K shows the composition of the meat cut from the tails of the animals. Here also we see a large excess of fat, a correspondingly small proportion of water and of nitrogenous bodies and of ash. The tail meats are not very concordant in their composition, there being large extremes shown in the proportions of the various constituents. This is in a large measure due to the carelessness of the cutters, as in some cases large quantities of fatty tissue were left connected with the cut designated as "tail," while in other cases the same portions of the animals were placed with the "trimmings." The largest amount of water in the tail meats is in the Tamworth, and the smallest in the Duroc Jersey, No. 5. The largest quantity of fat is found in the Duroc Jersey, No, 5, and the smallest in the Tamworth. The summation of the analyses here is also very satisfactory.

Average of all cuts.—Table 9 contains the average analyses of the meats of all of the cuts from each of the animals. These analyses were calculated from the preceding data, combining all of the meats into one expression for each animal. These data are true averages; that is, each part making up the mean in each case was given a weight according to the actual amount of matter which it represented. The data therefore show in a condensed form the variations between the composition of the meats of the different animals. It would not be fair to ascribe the differences which are noticed in the composition of the meats solely to the influence of the breed, because with the exception of one instance, where there are three animals of one breed, each breed is represented only by a single animal. In the case mentioned, however, where there are three animals representing the Duroc Jersey, it is seen that there is a marked agreement in the meat from each one. It is, therefore, fair to presume that the single animal for the other breeds represents fairly well types of that breed. With this statement the data have a greater value as showing the comparison between the meat of breeds than they would have had had there been only a single Duroc Jersey in the list. A study of the data shows that the Berkshire pig leads all others in having the maximum percentage of water and the minimum percentage of fat. The Berkshire, therefore, pound for pound, represents the least nutritive value of any of the breeds examined. Notwithstanding this fact, the Berkshire heads the list of all in its percentage of nitrogenous substances, and this compensates in a large degree for its increased percentage of water. There is quite a satisfactory agreement between the nitrogenous substances in the distribution thereof in the three classes named. The percentage of gelatinoid nitrogenous matters is fairly constant, only in one instance, namely, that of the Yorkshire, rising much above the average. All the other percentages are very near that of the mean.

In regard to the flesh bases, only one falls considerably below the average, namely, the Duroc Jersey, No. 7, the others being very close to the mean. In total nitrogen there is a marked deficit in the case of the Duroc Jersey, No. 7, but this is due not to the influence of breed alone upon the composition, but to the large excess of fat in the meat of this animal.

The ash shows a fairly constant number throughout, varying very little from the mean.

The summation of the analyses is fairly satisfactory. In no case is there as much as 2 per cent unaccounted for, the largest deficit being in the case of the Poland China, where it amounts to 1.55 per cent. When the nature of the material upon which the work was done is considered, the figures are eminently satisfactory. These data afford, it is believed, a better basis for nutritive studies of the meats of pigs than has heretofore been supplied from any chemical laboratory.

Average of bones.—Table 10 contains the average composition of all the bones of each animal. No separate analyses of the bones from each cut were made. For each pig one composite sample was made, including all the bones of the animal. As is to be expected in a case of this kind, it was found that the composition of the bones is reasonably uniform in the different animals. In regard to water, the largest quantity was found in the bones of the Poland China, namely, 42.70, and the smallest in the bones of the Duroc Jersey, No. 6, namely, 33.78 per cent. In regard to the content of fat, the largest quantity was found in the bones of the Duroc Jersey, No. 6, namely, 17.64 per cent, and the smallest in the bones of the Poland China, namely, 9.87 per cent. The bones are extremely rich in nitrogenous substances, and these consist mostly of the proteid matter insoluble in hot water. The quantity of gelatinous matter in bones is not so great as would be expected, being but little more, as a rule, than in the meats. On the other hand, the quantity of flesh bases is larger than would be expected, being considerably in excess of the quantity of gelatinous matter. The total quantity of nitrogenous matter in the different animals is remarkably near the mean, the mean quantity being 19.95 per cent and the variation not being quite 2 per cent in any case from the mean. The ash, naturally, is very high. The summation of the analyses is not as uniform as could be wished, ranging from 100.90 per cent as the maximum to 95.86 per cent as the minimum, a difference of little over 5 per cent. The difficulty of comminuting the bones into a homogeneous mass, and thus securing an average sample, probably accounts for a great deal of the discrepancy seen in the summations of the analyses. It is evident that the bones contain a very large amount of nutrient matter which would be available for digestion if they were sufficiently comminuted, since the ash consists almost exclusively of tricalcium phosphate, which is insoluble, and thus would not interfere greatly with the process of digestion. The bones of animals, however, are so valuable for fertilizing purposes that they have not been used to any extent for feeding, except for poultry.

Average of marrow.—Table 11 contains the average analyses of the samples of marrow from all the bones from each cut of each animal, except in the case of Duroc Jerseys, Nos. 6 and 7, where the samples of marrow were destroyed by mice. On account of the small amount of material at our disposal, the ash in the samples was not determined. The summation, therefore, represents only partially the total ingredients, since it does not include the ash nor the lecithin, which are very important components of the marrow substance. The marrow, as will be seen by the data, is essentially a fat product, more than 95 per cent of the whole weight of the material being composed of fat and water, the mean percentage of fat in the whole sample being 81.13, and of water, 14.57. The nitrogenous constituents of the marrow, while being extremely important from a physiological point of view, have not much value from a nutritive point. They constitute only 2.29 per cent of the whole. There is a fairly good concordance seen in the composition of the marrow from the different animals. In point of fat, the greatest variations are found in case of the Tamworth, with a maximum percentage of fat, and the Poland China, with a minimum percentage, the difference being, in round numbers, 16 per cent. The variations in water are less marked, while in the total nitrogenous matters only one, namely, the Tamworth, falls far below the others in the percentage contained. The summation is as good as could be expected, considering the fact that ingredients of considerable magnitude are omitted.

Average of skin.—Table 12 contains the average analytical data for the skin of all of the cuts of each animal. All the skin from each animal was mixed together and carefully comminuted by passing several times through a meat chopper until a homogeneous mass was obtained. From this mass a suitable sample was taken, representing as nearly as possible the average composition of the whole. On this were performed the analytical operations from which the data represented in Table 12 were secured. The table contains the analytical data for all the animals except No. 8, the Yorkshire, of which the sample was lost. The most remarkable fact in connection with a general view of the data is that the skins have a high rank among the nitrogenous substances of the animal. The mean percentage of nitrogenous matters in the skin is 26.35, and as the skin consists of almost half its weight of water, it is seen that the dry skin would contain 50 per cent of its weight of nitrogenous materials. The next most important ingredient is of course the fat, of which the average is 22.89. In the nitrogenous substances the proteids comprise about half of the whole. Of the other half two-thirds belong to the gelatinoids and one-third to the flesh bases. The skin, therefore, is preeminently a gelatinous body. About one-half of the total quantity of nitrogenous substances it contains is soluble in hot water, and one-third of the half which is soluble is not precipitated by bromin. If the gelatinous matters of the skin could be easily separated, they would be the most valuable parts of the animal for the preparation of the flesh bases. Skins of animals, however, are usually more valuable for the manufacture of leather than for any other purposes.

To go a little more into the detail of the data representing the composition of the skin, we find that the skin which had the largest percentage of water belonged to the Tamworth pig, and the one with the smallest to the Duroc Jersey, No. 5. Of fat the largest amount was found in the Duroc Jersey, No. 5, thus showing again the general relation of the proportions of water and fat to which attention has already been called. The smallest percentage of fat was found also in the case of the skin of the Tamworth, where the percentage of water was largest. In regard to nitrogenous substances the most remarkable variations are seen. In the Berkshire, which contained the largest proportion of nitrogenous substances, the true proteids comprise by far the larger portion, followed by the gelatinoids, while the flesh bases form a very small percentage of the whole. On the other hand, in the skin of the Duroc Jersey, No. 5 the quantity of proteids is comparatively small, while both the gelatinoids and flesh bases are high. Whether this marked peculiarity in the composition of the skin is due to the influence of the breed or to accidental causes can not be stated. Probably, however, it is due to accidental causes; as, for instance, the Chester White and the Duroc Jersey, No. 5 show similar composition of skins, but this is quite different from the composition of the skin of Duroc Jerseys, Nos. 6 and 7. It is possible, further, that owing to the peculiar structure of the skin and the difficulty of securing a homogeneous mixture of it, portions of the skin from different cuts vary relatively in the sample which was taken for analysis. Thus, for instance, if a portion of the skin very rich in gelatinous matter and flesh bases should form an excessive portion of the whole sample taken for analysis, the effect would be the same as is seen in the data recorded. The summation of the analyses is generally satisfactory, yet in one case there is a deficit of 9 per cent, while in another there is an excess of 1.70 per cent. These variations are doubtless due to the difficulty of securing a homogeneous sample for analytical purposes. Another source of unreliability in the samples of skin is found in the difficulty of avoiding variations in the amount of the underlying fatty tissue included in the sample. It is practically impossible to remove all of the tissue properly belonging with the skin without including a small quantity of the adjacent fatty tissue.

Average of spinal cord.—Table 13 contains the analytical data obtained in regard to the spinal cords of the different animals. Besides the spinal cords proper, these samples included the layer of fatty matter which surrounds the spinal cord in the spinal canal. In some instances the quantity of material was not sufficient to make a determination of the ash, and in three instances the whole of the material was lost. The data show great variations in the composition of the spinal cords of different animals, especially in the content of fat and water. The Berkshire had a spinal cord in which the water predominated, while in Duroc Jersey, No. 7, the fat was the predominant constituent. The nitrogenous substances are not so large as would be expected in nerve tissue, and those which are present consist chiefly of the proteids and gelatinoids, the flesh bases being only in relatively small quantity.

Average of tendons.—Table 14 contains the analytical data for the tendons of the animals, with the exception of two cases where the samples were lost. Considerably more than half of the tendons in the fresh state is water, while the fat, as is to be expected, is quite low. The nitrogenous substances, next to the water, constitute the chief material in the tendons, showing the largest percentage of nitrogenous matters of any part of the animal, with the exception of the hoofs. The true proteids and gelatinoids constitute by far the largest portion of the nitrogenous substances, the flesh bases being in relatively smaller proportion. The ash in the tendons is higher than in the meats. The summation of the analyses shows uniformly more than 100 per cent, which is probably due to the use of too large a factor in computing the proteids of the different classes from the percentage of nitrogen. Variations in the composition of the tendons are sufficiently well shown in the footings of maxima and minima. The variation in the content of water is not great, while in fat the range is a very considerable one, as indicated by the percentages. The agreement in the percentage of nitrogenous substances is quite close, the tendons showing very little variation from a mean composition. The ash is also quite constant, the range of variation not being very great, except in the case of the Poland China.

Average of hoofs.—Table 15 contains the analytical data relating to the hoofs of the animals. The fat content of the hoof is extremely small, while water constitutes almost half the entire weight of this substance. The nitrogenous substances were not separated into three portions, but were all estimated as proteids by multiplying the nitrogen content by the factor 6.25. Considerably more than half of the total weight of the hoofs in the fresh state consists of nitrogenous material. The ash is not very high, only in one instance exceeding 1 per cent. The summation of the analyses shows in every case more than 100, except in the instance of the Duroc Jersey, and this is doubtless due to using the factor 6.25 in computing the total amount of nitrogenous substances, inasmuch as the factor for the flesh bases, which were not determined in this case, is considerably lower than the one just mentioned.

LOSS OF WEIGHT IN TRANSPORTATION.

Table 16 shows a comparison of the weights of the entire animal and the various cuts, as determined in Chicago and in Washington, showing the percentage of gain or loss in transit. The weights in Chicago presumably were made with great care, but were not controlled by any employee of the Division of Chemistry. The weights in Washington were made directly by the Division of Chemistry, and can be certified as absolutely correct. In five instances the weights ascertained in Washington were less than those ascertained in Chicago, and in three instances greater. The largest variation between the two weights was shown in the case of the Chester White, where the loss was 8.07 per cent of the whole weight. The smallest variation was found in the case of the Duroc Jersey, No. 6, with a loss of 0.27 per cent. The largest gain in weight was in Duroc Jersey, No. 5, namely, 1.18 per cent, and the smallest gain in weight was found in the Yorkshire, namely, 0.49 per cent. The table contains not only the total weight of the animal in pounds and grams, but also the weight of each cut.

RATIOS OF MEAT, BONES, ETC., TO TOTAL WEIGHT.

Table 17 contains the relative percentages of the different parts of the animals, excluding the head, leaf lard, and kidneys, which had been removed before shipping from Chicago. This table is of great practical and economical interest, showing the relative percentages of each constituent of the animal, based upon its entire weight. In the animals dressed as received by us it is seen that nearly 89 per cent of the total weight of the animal is meat (fat and lean), a little over 6.25 per cent bones, nearly 4.75 per cent skin, 0.16 per cent tendons, 0.12 per cent marrow, 0.08 per cent spinal cord, and 0.08 per cent hoofs. There is quite a remarkable agreement in the relative proportions of these different constituents in the different animals. For instance, the widest variation from the mean in the percentages of meat in the animals examined was, in round numbers, only 2 per cent, while in the case of the bones it was numerically no larger, although relatively the variation was very much greater. In the case of the skin also the variation was not very marked. In the minor constituents the percentage of variation is great, but the actual variation in the different animals small. In regard to bones, the largest percentage was found in the Tamworth, and the smallest in the Duroc Jersey, No. 6. These show the extreme variations, and indicate that the Tamworth has a much stronger skeleton, so far as shown by weight alone, than the Duroc Jersey, No. 6.

PERCENTAGES OF THE SEVERAL CONSTITUENTS.

Table 18 contains the percentages of the different constituents of the entire dressed animal, excluding the head, leaf lard, and kidneys. The data are most interesting from a practical point of view. It is seen that of the entire animals 36.43 per cent was composed of water, 49.67 per cent of fat, 10.46 per cent of nitrogenous matter, and 2.11 per cent of ash. It may excite remark that the percentage of ash in the animal is so small when it is remembered that the whole of the mineral matter of the bones is included with the ash, but by referring to the table of the analyses of the bones it is seen that only about 25 per cent of their total weight is mineral matter, the rest being composed of water and organic substances. The water and the organic substances are included in the other data, and the ash therefore expresses only the mineral matters of the animal, including not only the bones, but also the mineral matters of the other tissues. In regard to the nitrogenous substances, their proportionate division into three classes is of interest. It is seen that of the whole amount 8.12 per cent belong to the proteids insoluble in hot water, and 1.10 per cent to the proteids of a gelatinoid nature, while 1.14 per cent belongs to the nitrogenous bodies representing the flesh bases. From a nutritive point of view, the true proteids are the most valuable. The gelatinoids are highly nutritious, but on account of their smaller quantity do not have so high an economic importance from a nutritive point of view as the other proteids. The flesh bases have a lower nutritive value, but are prized in many cases on account of their ready absorption and their stimulating properties, being already in a state suitable for partial assimilation. The summation of the analyses as a whole is extremely satisfactory, only a little over 1 per cent of the total weight of the animal being unaccounted for in the actual data obtained.

Comparison of breeds.—In regard to the details of the various constituents, it is seen that the Berkshire leads all the others in the percentage of water, namely, 43.10. The smallest percentage of water is in the Duroc Jersey, No. 6, namely, 30.31. The largest percentage of fat is found in Duroc Jersey, No. 7, namely, 57.68, and the smallest in the Berkshire, namely, 40.46. Of the total nitrogenous substances, the largest quantity is found in the Berkshire, namely, 13.02, and the smallest in the Duroc Jersey, No. 7, namely, 8.96. It is evident from an inspection of the table that the meat of the Berkshire is better for the production of muscular strength, while that of the Duroc Jersey, No. 7 is best suited for the production of animal heat. The Berkshire meat would be best suited for the use of our army in Cuba, while the meat of the Duroc Jersey, No. 7 would be best suited for the miners of the Klondike. These remarks are made without any expression of opinion concerning the type as a whole, but only on the data obtained from the two animals. The examination of a large number of typical animals of each of the breeds would be necessary to establish a definite rule of that kind. It is fair to presume, however, that the single animal is to a certain extent typical, and therefore represents to that extent racial characteristics.

LECITHIN.

The determination of lecithin in meat products is accomplished, as has been already described, by an indirect method; namely, by the extraction of the lecithin with a mixture of ether and alcohol and the determination of the phosphorus in the extract. From the quantity of phosphorus determined the percentage of lecithin is calculated by factors based upon the percentage composition of the lecithin itself. The data given for the lecithin should be accepted with certain restrictions, based upon the difficulty of applying the analytical processes. In the extraction of the fat by ether a certain quantity of the lecithin is removed. If, now, the residual lecithin be determined in the undissolved matters, namely, the dry flesh, the quantity obtained does not represent fully the whole amount originally present, but rather the quantity present in the muscular tissue itself. Therefore, in case of the meats especially, the data must be accepted as showing the quantity of lecithin in the fleshy portions of the meat, and not the quantity originally present in the fleshy portions plus the fat. In the case of the marrow and spinal cord, another difficulty presents itself; namely, that there was not a sufficient quantity of the material on which to perform the whole of the analytical operations. Inasmuch as the ether extract comprises a large percentage of the whole weight of these bodies, it is evident that the determination of the lecithin in this extract represents approximately the quantity present in the original material. On account of the paucity of this material, therefore, the lecithin was determined in these cases in the ether extract alone. If, however, the quantity be desired for the whole material, it is evident that the data given are not sufficiently large.

PHYSIOLOGICAL IMPORTANCE.

From a physiological point of view lecithin is of prime importance. It is quite certain that this body forms the transition state between the phosphates of the animal body on the one hand and the mineral phosphates absorbed by plants on the other. In the growth of plants the mineral phosphates are converted, to a certain extent, into lecithin, which is found especially in the seeds, those of an oily nature predominating in lecithin bodies. In the consumption of vegetable foods by animals the lecithin doubtless plays an important function in being transformed again into a mineral compound, namely, the tricalcium phosphate of the bones. Other portions of the lecithin become assimilated in the tissues of the body, and especially in the brain, spinal cord, and marrow. In the consumption of animal products by other animals lecithin again plays an important rôle in nutrition, forming on the one hand the bony structure of the animal eating the flesh, and on the other being again stored as lecithin in the tissues above mentioned. The data given, therefore, in the foregoing analyses are of great importance not only from their scientific interest, but also in representing in a general way the distribution of the lecithin in the various tissues of the body.

DISCUSSION OF THE LECITHIN IN PARTICULAR SAMPLES.

Lecithin in the meat.—In Table 9 it is seen that the mean percentage of lecithin in the residue after extracting the fat from the meats is 0.23. Inasmuch as almost the whole of the lecithin of the meats is found in the muscular tissues, this represents pretty fully the whole amount present in the original sample. The quantity, however, of lecithin in the fat extracted by the ether must not be neglected if we are to consider the total amount present in the original samples. It is noticed that there is a considerable degree of variation in the percentage of lecithin in the different animals, the minimum quantity being found in the Duroc Jersey, No. 5, and the maximum in the Duroc Jersey, No. 7. It is evident, therefore, that this variation is not to be ascribed to the influence of breed alone.

Lecithin in the bones.—The quantity of lecithin in the bones is considerably greater than that found in the meats, the mean being 0.31 per cent. In one instance, namely, the Duroc Jersey, No. 7, the lecithin was determined both in the residual bony matter and in the fat which was extracted. A great difference is noticed in the distribution of the lecithin among the various animals, the maximum quantity being found in the Poland China and the minimum in the Tamworth.

Lecithin in the marrow.—The quantity of marrow was so small that the only possibility of determining the lecithin was in the original ether extract. The data, therefore, are not as reliable as those ascertained by determining the lecithin in the extract after removal of the fat. In each instance the amount of lecithin was very small, except in the case of the Berkshire, where it was quite high.

Lecithin in the skins.—The mean quantity of lecithin in the skin was found to be 0.19; the maximum being 0.41 and the minimum 0.06. In three instances the lecithin was determined in the samples both after extracting with ether and in the ether extract. These cases are appropriately marked in the analytical tables.

Lecithin in the spinal cord.—Lecithin in the spinal cord was determined only in the materials extracted by ether. As was to be expected, the quantity is very high; the mean percentage being 1.54, the maximum 2.95, and the minimum 0.70. On account of the small quantity of the material it was not possible to determine the lecithin in the residue after the removal of the fat. If this could have been determined it is evident that the quantity of lecithin would have been very materially increased.

Lecithin in the tendons.—In one instance, namely, the Berkshire, the determination was made both in the extracted fat and the residue. In this case the quantity of lecithins is quite high. The mean for all the tendons, as determined, was 0.19, with a maximum of 0.45 and a minimum of 0.08.

In Table 18 the total percentages of lecithin in the whole animal, with the exceptions noted in several of the tables, are found. The mean percentage is 0.23, the maximum 0.42, and the minimum 0.11.

In submitting the above discussion it is but just to state that at the commencement of the analytical examination it was not our purpose to determine the lecithin at all. Had it been so, the determinations would have been made in a somewhat more satisfactory manner. The data, however, as submitted are, nevertheless, valuable, and with the restrictions noted in the different tables may be relied upon as a basis for economic studies.

CONCLUDING OBSERVATIONS.

In conclusion it may be stated that although work of the kind which has just been discussed is extremely onerous and time-consuming, yet it appears from a study of the results obtained to be a further contribution to our knowledge of dietetic science. All systems of true dietetic studies must rest first of all upon well-established chemical data. No valuable conclusions in regard to the dietetic value of any food can be obtained without first having ascertained its exact chemical composition. This having been done, the further study of its dietetic value rests also upon its chemical properties, as, for instance, the coefficients of digestibility. It appears advisable, therefore, considering the character of the data which have been presented, to recommend that studies of this kind be continued with all the classes of animals used as foods in this country. It would be advisable, if possible, that in studies of this kind, the animals be slaughtered at or near the point where the chemical examination is to be made; or, if this be not convenient, that a representative of the Chemical Division be present at the time of the slaughtering for the purpose of ascertaining the quantities of blood, hair, and excreta from the different animals and obtaining representative samples thereof for chemical examination.

Our systems of feeding and our environment develop types of animals which are quite distinct from those grown in other lands, and therefore the data which are obtained on animals in other countries are not strictly applicable to studies of the economic science of food production and food composition in this country.

APPENDIX.

For full particulars relative to the general principles of the separation of the different forms of nitrogenous bodies the reader is referred to the Principles and Practice of Agricultural Analysis, volume 3, and to Bulletin No. 54 of this Division. An abstract of the literature relating to the separation of flesh bases from other nitrogenous bodies is given here.

PRECIPITATION OF PROTEIDS SOLUBLE IN WATER BY CHLORIN AND BROMIN.[1]

Rideal and Stewart recall some of the experiments made in 1876, in which it was shown that a current of chlorin gas conducted through an aqueous solution of proteid matters produces a precipitate which is of a quite constant composition, and one which can be collected, dried in vacuo, and weighed. They describe particularly the use of this reagent in precipitating gelatin prepared from the high grade commercial article. They show that the total quantity of gelatin can be accounted for from the weight of the precipitate by multiplying the weight of the precipitate obtained by the factor 0.78. The authors also point out the possibility of using bromin in place of chlorin for the precipitation, and state that the studies of the use of bromin are under way. They call attention also to the fact that as early as 1840 chlorin had been used by Mulder for the precipitation of soluble proteids, and refer to a paper of his published in Berzelius's Jahresbericht, volume 19, page 734, in which he obtained results on precipitation quite similar to those secured by Rideal and Stewart.

Other references to the literature on the subject are also given, viz: De Vrij, Ann. Pharm., lxi, 248; Thénard, Mém. d'Arcuéil, ii, 38; Mulder, Bulletin en Néerlande, 1839, 153; and Berzelius' Jahresbericht, xix, 729.

Allen and Searle, acting on the suggestion of Rideal and Stewart, worked out the bromin method by applying it to various soluble proteids, including the whole range from albumin to peptone. In the application of this test to commercial gelatin 50 grams of commercial gelatin are dissolved in warm water and the solution diluted to half a liter. In 10 c. c. of this solution, corresponding to 1 gram of the gelatin, the nitrogen is determined directly by the Gunning-Kjeldahl process.

Another portion of 10 c. c. is treated with an excess of bromin. The solution is first brought to a volume of 100 c. c. with water and placed in a conical beaker with a sufficient quantity of hydrochloric acid to produce distinct acidity. A saturated solution of bromin water is added in considerable excess and the liquid stirred vigorously for some time. The precipitate which separates is flocculent when first formed, but becomes more viscous after stirring and adheres for the most part to the sides of the beaker, which, with its contents, is allowed to stand for about half an hour, or until all the precipitate is settled. The supernatant liquor is decanted through an asbestos filter. The precipitate adhering to the beaker is washed several times with cold distilled water and the washings poured through the filter. Occasionally, when most of the free bromin is washed out of the precipitate, the liquid does not filter clear. It is therefore advisable to keep the washing separated from the filtrate, and, if necessary, wash with sodium sulphate solution or with bromin water. The nitrogen in the precipitate is determined by the Gunning-Kjeldahl process as follows:—

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[1] The Analyst, **22**, pp. 228 and following; also pp. 255 and following.

The precipitate which has been collected on the asbestos filter, together with the asbestos, is returned to the beaker in which the precipitation took place. Twenty cubic centimeters of strong sulphuric acid are added, the beaker covered with a watch glass and placed on a wire gauze over a lamp. When frothing has ceased about 10 grams of powdered potassium sulphate are added and the liquid boiled until colorless. After cooling it is diluted with water and the ammonia distilled off and determined in the usual way. The percentage of nitrogen found, when multiplied by the factor 6.33, or, in the case of gelatin, by 5.5, gives the amount of proteid matter precipitated by bromin. In the commercial gelatin above mentioned the nitrogen content was found to be 14.1 and 14 per cent, respectively, on two determinations. Solutions of creatinin, asparagin, and aspartic acid were found to yield no precipitates with bromin, but bromin was found to precipitate all albumin, acid albumin, and all peptones formed by the digestion of albumin with pepsin.

NITROGEN IN MEAT EXTRACTS.

On applying the bromin method to commercial meat extracts the following results were obtained. The solutions of the Bovril preparations were not previously filtered and therefore the figures contain the nitrogen in the fiber present:

Relative amounts of nitrogen in meat extracts.

	Nitrogen in precipitate by bromin.	N×6.33 = proteids.
	Per cent.	*Per cent.*
Liebig Company's extract	1.41	8.92
Seasoned bovril	1.94	12.28
Bovril for invalids	2.64	16.71

Koenig and Boemer have shown that the proteid nitrogen in meat extracts is generally much overestimated. They found a total of 1.17 per cent of proteid nitrogen in the Liebig Company's extract, which is equivalent to 7.41 per cent of total proteids, mostly albumose.

PROBLEMS SOLVED BY THE BROMIN METHOD.

The fact that bromin completely precipitates all proteid and gelatinoid matters in solution affords a convenient means of solving certain problems which have hitherto presented considerable difficulty. For instance, in a solution which has been subjected to digestion it may be possible to precipitate all the unchanged proteids by saturation with zinc sulphate. The peptones which have been formed during digestion remain in solution and can be separated by filtration. In the filtrate the peptones can be completely precipitated by bromin, and thus the total quantity of these bodies formed during digestion can be accurately determined.

Allen and Searle applied this method to an examination of the Liebig Company's extract, 5 grams of which were dissolved in 100 c. c. of water and the solution saturated with zinc sulphate. After filtering, bromin water was added to the filtrate and a precipitate produced which redissolved on diluting with water and the addition of hydrochloric acid. When the filtrate from the saturated zinc sulphate was previously diluted with water and acidulated no precipitate was formed on the addition of bromin. This reaction shows that no considerable quantities of real peptones exist in Liebig's extract.

BULLETIN NO. 54.

U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF CHEMISTRY.

REPORT

ON

AN INVESTIGATION OF ANALYTICAL METHODS FOR DISTINGUISHING BETWEEN THE NITROGEN OF PROTEIDS AND THAT OF THE SIMPLER AMIDS OR AMIDO-ACIDS.

BY

J. W. MALLET,

Professor of Chemistry, University of Virginia.

WITH

A CHAPTER ON THE SEPARATION OF FLESH BASES FROM PROTEID MATTERS BY MEANS OF BROMIN.

BY

H. W. WILEY,

Chief of Division of Chemistry.

WASHINGTON:
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1898.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF CHEMISTRY,
Washington, D. C., July 9, 1898.

SIR: In accordance with your request of April 15, I have carefully read the manuscript submitted by Prof. J. W. Mallet, being a result of the investigation of analytical methods for distinguishing between the nitrogen of proteids and that of the simpler amids or amido-acids.

This investigation was undertaken by Professor Mallet at the suggestion of the Office of Experiment Stations, and under the immediate direction of the director of that office and of Prof. W. O. Atwater, special agent. The work being purely of a chemical character, it was, at your suggestion, and with the assent of Drs. True and Atwater, submitted to this office for inspection. The investigation consists in a chemical study of the methods of quantitative analysis employed in the separation of proteid and amid bodies, especially in animal products. The results are similar in their scope to the chapter on this subject contained in my work on the Principles and Practice of Agricultural Analysis, vol. 3.

Professor Mallet has stated in an admirable manner the different methods which have been proposed for the separation of proteid matters in animal products. By a happy modification of the phosphotungstic acid method he has greatly improved this process, and shown how a practical separation of the flesh bases from the other nitrogenous substances can be effected by this reagent. The flesh bases are to some extent precipitated by the new form of the reagent proposed by Professor Mallet, but they are brought into a soluble state by the addition of water and heat, so that a practically complete separation of them is effected. This process, together with the use of tannic acid for the separation of peptones, leaves little to be desired in securing a practically complete separation of the nitrogenous matters. The analytical processes proposed have been thoroughly worked out by experiment upon products of known composition, so that their reliability has been by this means more firmly established.

One of the most useful and simple methods of separating proteid matters into insoluble and gelatinoid proteids, and of separating these two classes from the flesh bases, is by the use of hot water, followed by the use of chlorin or bromin—a method not mentioned either in the Principles and Practice of Agricultural Analysis, above referred to, nor in Professor Mallet's paper. This method, which has lately come into use, has been thoroughly worked out in this laboratory and applied in a long series of analyses of flesh products. It is so superior in every respect to the methods in ordinary use that it appears destined to entirely replace them. I have therefore added an outline of this method as an appendix to Professor Mallet's report.

I submit this manuscript with the request that it be published as Bulletin No. 54 of the Division of Chemistry.

I am, respectfully,

H. W. WILEY,
Chief of Division.

Hon. JAMES WILSON,
Secretary of Agriculture.

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ANALYTICAL METHODS FOR DISTINGUISHING BETWEEN NITROGEN OF PROTEIDS AND NITROGEN OF SIMPLER AMIDS OR AMIDO-ACIDS.

DISCUSSION OF MATERIALS AND CONDITIONS.

It is admitted by all who have had experience in the chemical analysis of materials used as food that the common practice of determining the total nitrogen in such materials by multiplying the result by 6.25 and calling the product so obtained "protein," is but a crude and clumsy way of approximately representing the value of the material under examination as respects its nitrogenous constituents. Besides the substances which are properly designated as proteids there are other nitrogenous constituents of food materials which differ widely from these in nutritive value and some of which also differ greatly from these and from each other in the proportion of nitrogen which they contain.

CLASSES OF NITROGENOUS CONSTITUENTS IN FOODS.

The following classes of the nitrogenous constituents of food are commonly recognized as requiring separate consideration.

(1) Proteids proper (by some called albuminoids), and their closely related derivatives, the proteoses and peptones.

(2) Gelatinoids or collagens, and allied substances immediately derived from them, such as gelatin, chondrin, etc.

(3) Simpler amids, amido-acids, and allied substances, such as the asparagin, glutamin, etc., of vegetable materials, and the "flesh bases" (kreatin, kreatinin, etc.) of animal origin.

(4) Alkaloids, or amine-like compounds of well-determined basic character.

(5) Ammonia and its salts.

(6) Nitrates.

To these, no doubt, should be added lecithin and analogous substances containing nitrogen but closely allied to the fats.

The known and commonly used methods for determining nitrogen in the forms of ammonia and nitrates, which occur but sparingly in food materials, may be considered fairly satisfactory. Alkaloids in the commonly accepted sense of the term demand attention only in connection with such special accessories of food as tea, coffee, and similar nervous stimulants, and the chief substances of alkaloidal character admit of being separately dealt with in these special cases without serious trouble and with a fair degree of accuracy.

It is with the first three of the above-named classes of food constituents that difficulty is encountered, and for which further study of methods is desirable. The object of the work which the writer has undertaken, and to which he has devoted a good deal of time for several months past, has been to study the means of distinguishing between the first and third of these classes of constituents, the proteids and related bodies on the one hand and the simpler amids and amido-acids—sometimes grouped together as "nitrogenous extractives"—on the other. Incidentally only, some experiments have been made with representatives of the gelatinoid class.

NUTRITIVE VALUES OF THREE CLASSES.

It is commonly assumed that proteids, gelatinoids, and the simpler amids have very different nutritive values, and while all authorities would agree in assigning the highest value to the first of these there is probably no small difference of opinion as to the order in which the second and third should be rated. In considering such a question, there should be separately taken into account relative digestibility or solubility, capability of undergoing osmotic absorption, and oxidizability in order to the production of energy. At present no definite numerical statement of the relative nutritive values of nitrogenous bodies of these three classes can be made. It seems much to be desired that more extended experiments than have so far been recorded should be made upon living animals—as far as possible upon human beings—in regard to the utilization of both the gelatinoids and the simpler amids. The latter no doubt undergo oxidation to some extent in the animal body, and produce some energy in consequence. It is probably true of these simpler amidic substances that much larger quantities than analysis exhibits as constituents of the food consumed or than analysis detects among the residua of food rejected from the body without having undergone complete oxidation, may be constantly formed among the earlier products of the metabolism of the proteids, and afterwards themselves undergo further change into the simpler and more stable forms of carbon dioxid, water, and urea.

LACK OF PRECISION IN CHEMICAL CONSTITUTION.

It must be admitted that to a chemist the question of distinguishing between the proteids and the simpler amids is not one of a scientifically precise character. The proteids doubtless contain at least a part of the nitrogen in the amidic relation, and where the line is to be drawn between more complex and more simple amids is, of course, more or less a matter to be arbitrarily decided. But, of greater importance still is the doubt whether any of the so-called proteids are entitled to recognition as definite chemical substances. We usually understand by the term "a definite chemical substance" a substance of which all the molecules are exactly alike in constitution. Thus to the chemist the identity of such a substance as pure common salt or cane sugar or caffeine depends on the absolute identity in character of all the myriad molecules of which even the smallest sensible mass is made up. But in regard to such materials as these we are able to determine the relative and absolute number of atoms of the elements of which each molecule is composed, and in many cases their order of attachment to each other, or the "structure" of the molecule. On the other hand, we have reason to believe that the so-called proteids are made up of molecules of such extreme complexity, assemblages of such large numbers—hundreds—of atoms of carbon, hydrogen, oxygen, and nitrogen, that we can make but random guesses at their arrangement, and can not even determine with any certainty their number, relative or absolute. We talk of albumin, myosin, syntonin, as if these terms stood for pure chemical substances in the same sense that attaches to ammonia, benzene, or urea. But it is by no means certain that in a specimen of the most carefully prepared albumin from blood or white of egg any hundred, or any ten, molecules are absolutely alike. It may well be that a minute specimen of such a material consists in reality of numerous more or less similar but yet in some respects different molecules, which we lump together under a single name merely because they have a general resemblance, with certain properties in common. Furthermore, in nutrition investigations we have to deal with articles of food representing complex mixtures of substances referable to the two classes of the proteids and nitrogenous extractives, with many other things besides. Hence, an answer to the question to be examined must be a limited one, and such only as may serve the limited purpose of practical application in connection with nutrition investigations. Any process of separation, to be of value in such application, must be reasonably simple, and capable of being carried out without too great consumption of time.

LIST OF SUBSTANCES EXAMINED.

A good deal of work was necessary at the outset in procuring satisfactory specimens of the several substances to be examined. Some of these have been prepared out and out in this laboratory from natural animal or vegetable sources. Some have been purchased in a more or less crude state and carefully purified. Some have been purchased, and their purity ascertained by testing.

The following representatives of the simpler amidic and imidic compounds were experimented with:

Amido-acids of the fatty series:
  - Glycocin (glycocoll or amido-acetic acid).
  - Alanin (a-amido-propionic acid).
  - Leucin (amido-caproic acid).

Amido-acids of the succinic acid and allied series:
  - Aspartic acid (amido-succinic acid).
  - Asparagin.
  - Glutamic acid (a-amido-oxyglutaric acid).
  - Glutamin.

Amido-acid, including a benzene nucleus:
  Tyrosin (oxy-phenyl-*a*-amido-propionic acid).
Betaine bases:
  Betaine.
Guanidine bases:
  Kreatin.
  Kreatinin.
Bases and neutral amids related to uric acid:
  Hypoxanthine (sarkine).
  Carnine.
  Allantoine.

As representatives of the proteids and allied substances the following were used:

Albumin, from white of egg.
Albumin, from blood.
Fibrin, from blood.
Casein, from milk.
Legumin, from peas.
Globulin (para-globulin), from serum of blood.
Vitellin, from yolk of egg.
Myosin, from muscular tissue.
Syntonin (acid-albumin), from muscular tissue.
Hæmoglobin (mainly oxy-hæmoglobin), from blood corpuscles.
Albumose, from egg albumin.
Peptone, from fibrin of blood.
Gelatin, from skin.
Chondrin, from cartilage.

SOLUTIONS USED IN EXPERIMENTS.

These were, for the experiments by precipitation, brought into solution as follows, involving, as will be seen, change of chemical constitution in some cases:

Albumin, Hæmoglobin, } dissolved in cold water.
Gelatin, Chondrin, } dissolved in hot water.
Fibrin, brought sparingly into solution by prolonged action of a 10 per cent solution of sodium chloride in water.
Fibrin, digested with a 4 per cent solution of caustic soda, and the solution afterwards acidified with acetic acid.
Casein, dissolved in 1 per cent solution of caustic soda, and the solution cautiously treated with dilute acetic acid to an extent just short of coagulation.
Globulin, dissolved in 5 per cent solution of sodium chlorid.
Vitellin, Myosin, } dissolved in 10 per cent solution of sodium chlorid.
Syntonin, dissolved in 0.1 per cent solution of hydrochloric acid.
Albumose, from the early stage of digestion of egg albumin by means of pepsin and 0.2 per cent solution of hydrochloric acid.
Peptone, from advanced stage of digestion of blood fibrin by means of trypsin and 0.25 per cent solution of sodium carbonate.

FOODS INVOLVED IN THE INVESTIGATION.

While it was especially desirable to ascertain the behavior of these several substances, of both classes, in their separate condition, it was borne in mind that in connection with nutrition investigations they have to be dealt with as constituents of ordinary food materials, principally the following:

Meats, including poultry and fish (raw and cooked), soups and stews, meat extracts, eggs, milk and cheese, bread and other farinaceous preparations such as cakes and pastry, fruits and raw table vegetables, cooked fruits and table vegetables, fruit conserves, undigested and unabsorbed residues of food.

It was assumed as probable that the same method (in detail) would not be best adapted to all cases, but would be likely to need modification in application under different conditions.

Of course, the investigation undertaken has gone over ground already well trodden, and the results recorded by Schulze, Barbieri, Sachsse, Kormann, Boemer, Huefner, Allen, Tankard, Chittenden, Osborne, Wiley, and others have been carefully examined.

The experimental work of the present investigation is reported, not altogether in the order in which it was done, but rather in logical succession, taking account first of physical differences between the classes of substances to be distinguished, then of the effects of chemical agents of decomposition, and, lastly, of relations to solution and precipitation.

METHODS OF SEPARATING NITROGEN.

A brief notice of several methods of separating nitrogen will afford means of comparison. The phospho-tungstic method which was especially investigated is treated more fully than the others.

DIALYSIS.

The attempt to separate such proteids as are soluble in water from the simpler amids intentionally mixed with them by applying Graham's method of dialysis was made with no great hope of success. It is, of course, well known that the amorphous proteids in solution exhibit as a class a very small degree of diffusive mobility, while the crystallizable, simpler amids diffuse through a porous septum, as of parchment paper, with much greater rapidity. But separation based on this difference can never be complete. Only a part of the more diffusible material can be obtained in the water on the opposite side of the diaphragm from the mixed solution, and that a large part shall be so obtained requires that the volume of water used shall be large as compared with the volume of the solution. Moreover, the absolute volume of the solution itself must be large where amids of but slight solubility, such as tyrosin, are present, in order that they may not be left behind in the undissolved state. But the time required for dialytic separation extends to many hours, or even several days, and during such protracted exposure to the air and to common atmospheric temperature weak solutions of the proteids readily undergo chemical change. Again, it is to be remembered that the peptones, classed with the proteids, are diffusible in much higher degree than natural proteid material prior to its exposure to the action of the digestive fluids. This fact has well-known physiological importance in its bearing on the preparation of proteid food for absorption from the alimentary canal, but in analysis it tends to confound the particular group of the peptones with the simpler amids. In the recovering from weak solutions of small quantities of dissolved substances by the evaporation of large amounts of water, further chemical change of the substance recovered is likely to vitiate the results.

Nevertheless, some twenty or more experiments were carried out with dialysers made from the tubes of parchment paper which can now be bought in Germany. Cylinders of about 6 inches long were cut from these tubes, and closed at one end by thin glass, carefully tested as to freedom from holes, and immersed in water contained in ordinary glass beakers. A fairly clean separation was obtained of leucin, aspartic acid, and kreatin from solutions to which had been added egg or serum albumin, the diffusate being in each case evaporated at a moderate temperature over the water bath, and the residue weighed. But the process of diffusion was inconveniently slow, and less satisfactory results were obtained when the dialyzed solution was made more complex by the addition of other substances.

Subsequently the writer's attention was attracted by the paper of Charles J. Martin[1] on the use for a like separation of a Pasteur filter in the pores of which a film of silicic acid has been deposited, the filtration being brought about under pressure. It has been practicable to make only two or three experiments in this way. The method is decidedly promising, but it seems more likely to be useful in the purification of substances in quantity than as a process of analysis. With small quantities of material it can hardly be made available for regular laboratory work in connection with nutrition investigations. It involves the same difficulty as any other form of dialysis in cases in which the proteoses and peptones are present.

INTERACTION WITH NITROUS ACID.

It was hoped that by varying the conditions of experiment with this reagent some characteristic differences of behavior might be observed as regards the evolution of elementary nitrogen.

The most advantageous mode of producing nitrous acid in definite amount was found to consist in bringing together, along with the material to be acted upon, pure silver nitrite and a hydrochloric-acid solution of known strength. The action took place in a glass flask of about 100 c. c. capacity, closed by a stopper through which passed the long neck of a cylindrical funnel holding about 60 c. c., the neck having an interior diameter of but 1 mm. and separated from the wider cylindrical reservoir by a well-ground glass stopcock. There also passed through the same stopper the stem of a thermometer reading to one-tenth of 1 degree with accuracy, a small tube with stopcock for the introduction of gas to displace the air of the apparatus, and a second small tube to carry off the nitrogen evolved. The capacity of the flask was carefully gauged with the tubes and thermometer in position and the stopper inserted to a marked depth in the neck, so that after the introduction of any known volume of solid or liquid material a simple subtraction would give the volume of gaseous matter remaining included. A gas-measuring cylinder, connected with the flask by a tube of very small bore and immersed in water in a larger cylinder which could be raised or lowered, provided for collecting and measuring the evolved nitrogen. The flask was supported in a water bath, so that it could be heated or cooled at pleasure.

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[1] Jour. Physiol., 1896, 20, pp. 361–371.

In order to give time for action upon the organic material under experiment, and to keep down to conveniently small limits the evolution of nitrogen dioxid, it was found important to work with the nitrous acid in a sufficiently diluted condition. With the same object in view it was found desirable to raise the temperature of the flask very gradually. In carrying out an experiment the particular amidic or proteid material was finely pulverized, weighed off, and introduced into the flask, either in the dry state or with as little recently boiled water as possible, and with the necessary amount of silver nitrite, as a fine crystalline powder. This powder was contained in a small, thin glass cylinder which could be easily upset in order to mix its contents with the other materials in the flask. A current of nitrogen gas was next run through the flask until all air was expelled. In the case of substances dissolving in water with difficulty the flask was now allowed to stand closed for some time to permit of solution taking place. Communication was established with the gas-measuring cylinder and the proper quantity of standard hydrochloric acid made by diluting very strong aqueous acid with boiled water and kept in small well-closed bottles, was gradually introduced through a funnel with capillary bore. Care was taken that no air was admitted. After all action in the cold had ceased the temperature of the flask was gradually raised by means of the water bath up to a maximum of about 96° or 97° C. As soon as all action was over and the apparatus had cooled down to atmospheric temperature the flask was nearly filled up with recently boiled water, introduced through the capillary funnel, and a small measured volume of nitrogen was run in to displace any remaining nitrogen dioxid. The gas in the measuring cylinder was then treated with oxygen in sufficient excess to dispose of all nitrogen dioxid and with caustic potash and pyrogallol to remove excess of oxygen. After standing at rest for some time the gas was measured, due allowance being made for the nitrogen present in the flask at first and for the small additional amount afterwards introduced. Of course, the proper corrections for pressure, temperature, and tension of aqueous vapor were made in connection with all the measurements of gas, and the quantity of nitrogen obtained was divided by 2, one half being yielded by the organic substance and the other by the nitrous acid.

With a view to guard against the retention of any nitrogen in the form of di-azo derivatives from amids, a moderate excess of hydrochloric acid was used. In the case of kreatinin the results are complicated by the formation of the supposed nitroso compounds observed by Dessaignes. With several of the proteids the bright yellow color of the so-called xantho-proteic acid was well marked, as the consequence, doubtless, of the action in the flask of nitric acid produced by the breaking up of nitrous acid into nitric acid, nitrogen dioxid and water. Too little is known of the yellow substance formed, Mulder's xantho-proteic acid, to indicate how far its nitrogen comes from the proteid and how far from the nitric acid, or in what direction or to what extent its formation may influence the amount of elementary nitrogen given off. In the case of proteid solutions coagulable by heat it was manifestly important to allow the action of the hydrochloric acid on the silver nitrite to become complete below the temperature of coagulation, as otherwise silver nitrite was entangled in clots of the coagulating proteid. In some, at least, of these experiments, it seemed probable that a part of the nitrogen dioxid given off, and perhaps of the free nitrogen, was due to the reducing action of the carbon or hydrogen of the organic substance upon nitrous or nitric acid, and not solely to the normal interaction of nitrous acid and the amidogen radicle present.

The process was varied, not only in respect to the temperature applied, but also, within moderate limits, in respect to the pressure on raising or lowering the gas-measuring tube in the water. It was further varied by increasing the proportion of nitrous acid to different extents in excess of the theoretically necessary amount.

In all some fifty or sixty experiments were made. In a number of cases the simpler amidic compounds gave a fair approximation to the quantity of nitrogen theoretically to be expected from them, though even with such substances as leucin, asparagin, and aspartic acid the results were not as sharp as the claims of Sachsse and Kormann would lead one to suspect. One of the best experiments yielded for aspartic acid 9.57 per cent of nitrogen, instead of the 10.53 per cent actually present. Kreatin did not give one-half of its nitrogen, as has been heretofore recorded as the fact, but a somewhat nearer approach to one-third—10.19 per cent as against 32.06 per cent—the probability of which result is indicated by the accepted structure of the molecule. In all cases the proteids gave some nitrogen, but the proportion was much smaller than from the simpler amids, and varied much more with the precise conditions of temperature, pressure, and strength of solution used. In one experiment serum albumen gave but 2.68 per cent, and in another but 2.92 per cent was obtained from hæmoglobin.

On the whole, the indications pointed to the simpler amids and amido-acids being most easily decomposed by nitrous acid, the proteoses and peptones perhaps next, and the proteids proper least. But no differences were observed upon which any useful analytical process ot separation or distinction could be based. Experiments made in this way are, moreover, troublesome, and require strict observance of the necessary precautions to avoid error from introduction of air into the apparatus and its action on nitrogen dioxid.

INTERACTION WITH POTASSIUM PERMANGANATE IN PRESENCE OF FREE ACID OR ALKALI.

The writer had not much hope of obtaining useful results by this method, in view of former experience gained in connection with the extended research upon the determination of organic matter in drinking water carried out many years ago for the U. S. National Board of Health, of which the results were published in the annual report of that board for 1882. Still, as the work then done was upon extremely dilute solutions, comparable in respect to the amount of organic matter present with natural potable waters, it seemed possible that results not altogether of the same sort might be obtained with solutions of greater concentration. Hence some thirty or forty experiments were made with permanganate strongly acidified with sulphuric acid, and a rather larger number with the same salt after potassium hydroxid had been added in about the same proportion as is usual for the Wanklyn, Chapman, and Smith so-called albuminoid-ammonia process. In the former set of experiments the amount of oxygen withdrawn from the permanganate, and in the latter set the amount of ammonia produced, were determined. In both cases the reactions were carried out at various temperatures up to the boiling points of the several liquids.

Some difference was observable in the results obtained with the comparatively strong solutions used, such difference being more notable for alkaline than for acid permanganate. But in the main these results only confirmed the conclusions arrived at in the earlier research. The effect of the reagent employed is imperfect, and varies much with the nature of the individual organic materials tested; much, also, with the conditions of the experiment and with the rate at which the action proceeds. No valid evidence is obtained in support of Wanklyn's view that simple and definite fractions of the total nitrogen present are evolved as ammonia on treatment with alkaline permanganate.

Some special difficulties and sources of error already known were reobserved; as, for instance, the continuous evolution of ammonia by boiling many organic substances with alkaline permanganate until distillation has practically brought the contents of the retort to dryness, without all of the nitrogen present having been given off. And some other causes of trouble were noticed; as, for instance, the loss of oxygen given off as such from a strong and acid solution of permanganate on standing in a heated condition irrespective of action on the organic matter present.

The general tenor of the results in the case of the nitrogenous substances treated pointed to more energetic and extensive action of permanganate in alkaline than in acid solution; also to more extensive action on the simpler amidic compounds than on the proteids. But notwithstanding sundry variations of method as to strength of the reagent solutions, proportion of reagent to organic material acted on, temperature and time of action, no indication was obtained of any valid basis for distinction in analysis between the two classes of nitrogenous material studied.

INTERACTION WITH SODIUM HYPOBROMITE.

This reaction is so frequently used for the approximate determination of urea (carbamid), while its results with other amids have been so scantily examined and almost no facts bearing on its relation to the proteids have been recorded that a good deal of interest was felt in examining it somewhat extensively with the two classes of materials which were studied.

The solution of bromin was prepared with 240 grams of potassium bromid, 200 grams of free bromin, and enough water to make up a liter. The solution of caustic soda was made with 340 grams of pure sodium hydroxid to the liter. These solutions were preserved in separate bottles and equal volumes of the two were mixed just before using. When undiluted the mixture represented 0.1 gram of originally free bromin to each cubic centimeter and was in most of the experiments used of this strength; but various dilutions were also employed, being made by additions of water in definite amount.

The apparatus with which the reaction was carried out was essentially the same as that adopted for the experiments with nitrous acid, save that the small tube was omitted which was intended to introduce an inert gas to displace air from the apparatus, this precaution being unnecessary in the hypobromite experiments.

Nearly 80 experiments were made, varying the conditions as to temperature from that of the atmosphere, usually 15° to 20°, up to 96° to 98° C., as to pressure within the limits allowed by the immersion of the gas-measuring cylinder, and as to time from fifteen or twenty minutes up to five or six hours.

In some cases the results obtained were in agreement with those of the few hitherto recorded experiments—as, for instance, aspartic acid gave no nitrogen, as was found to be the fact by Allen and Tankard.

In other cases there was disagreement with some of the published statements and confirmation of others. Thus, Allen and Tankard obtained no nitrogen from glycocin,[1] and Tankard none from asparagin,[1] while Oechsner de Coninck reported both these substances as acted on (by sodium hypochlorite) when gently heated, nitrogen gas being evolved.[2] The writer obtained from glycocin 4.2 per cent of nitrogen instead of 18.67 per cent as required by the formula,[3] and from asparagin 11.12 per cent instead of 18.67 per cent, the amount calculated, taking account of the presence of a molecule of water of crystallization.

In a number of cases the quantity of nitrogen evolved from an amid or amido-acid of known constitution seemed to represent a simple fraction of the total quantity contained in the material operated on, and it might not unnaturally be suspected, as in some of the cases reported by Allen and Tankard, that one-fourth or one-half to two-thirds of the whole quantity was liberated. Thus in one experiment leucin gave 2.58 per cent of nitrogen instead of 10.69 (calculated), or about one-fourth; in another, kreatin gave 21.96 per cent instead of 32.06 (calculated), about two-thirds; and in another, hypoxanthine gave 18.80 per cent instead of 41.18 (calculated), which might mean one-half—two atoms out of four. But it is not believed there is any more real significance in these approximations to definite fractional parts of the nitrogen being evolved than in the similar approximations to which Wanklyn drew attention in connection with his so-called albuminoid-ammonia process. His conclusions have been shown to be entirely erroneous. Different figures could be obtained from the same materials acted on by varying the conditions of the experiment, and in some cases there was no really sharp ending to the reaction, traces of gas continuing to be slowly given off for hours after the main portion had been collected. Moreover, while our knowledge of the constitution of kreatin would make it not improbable that two atoms of nitrogen out of three should be liberated, or two out of four in the case of hypoxanthin, there is no similar ground for any expectation that leucin, containing but one atom of nitrogen in the molecule, should yield one-fourth; or glutamic acid, also with but one atom, should yield something like one-fourth (2.56 per cent instead of 9.52 calculated).

The researches of S. Hoogewerff and W. A. van Dorp have shown that numerous definite products other than elementary nitrogen may be formed by the action of alkalin hypobromites upon amids and amido-acids, especially those containing cyclic nuclei. In several of the writer's experiments—as, for instance, with alanin among the simpler amido-acids, and with a sample of globulin among the proteids—a crystalline residue separated out in the flask on cooling. This residue was not examined further than to determine qualitatively that it contained nitrogen. The proportion borne by the nitrogen left in such fixed residual products to that collected as gas evidently varied with the conditions of the particular experiment, as well as with the nature of the substance acted on.

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[1] A. H. Allen, Commercial Organic Analysis, 1896, Vol. III, Part III, p. 275. Possibly the solutions were not heated.

[2] Comptes rendus, 1895, **121**, 893–894. Jour. Chem. Soc. (London), (1896), Abstracts, org. chem., p. 282.

[3] In Watt's Dictionary of Chemistry, revised edition by M. M. Pattison Muir and H. F. Morley, Vol. II, p. 627, it is stated, on the authority of Denigès (Comptes rendus, **107**, 662), that with sodium hypobromite nitrogen is evolved from glycocin.

All the proteids and analogous materials treated gave some gaseous nitrogen. For the most part the amount was about two-fifths of the whole amount present; but occasionally a larger proportion, as in one experiment with globulin just about one-half, and in another with myosin about three fourths. In this last case the action was allowed to go on at a high temperature for a time much longer than usual. The remarks already made in regard to the simpler amidic substances, as to modification of results by variation of the conditions of experiments, fully apply also to the experiments with proteids and their congeners. The lack of sharpness of ending to the reaction was more noticeable with the latter class of materials than with the former.

Although these experiments with alkaline hypobromite were interesting, and occasionally offered points which might repay further investigation, they did not, taken altogether, afford any satisfactory basis for distinguishing in analysis between the classes of materials to be studied in contrast with each other.

BEHAVIOR WITH CUPRIC HYDROXID (STUTZER'S REAGENT).

The formation of insoluble compounds of the proteids with cupric hydroxid, while leaving the simpler amids soluble in the presence of an excess of this reagent, has been extensively adopted as the means of separation, but experiments made in this way have not given the writer much confidence in the method as a general one. In some cases, working with a proteid alone, the copper compound underwent partial solution, a blue liquid being formed, although care had been taken to avoid the presence of free alkali. Possibly this result was due to incipient decomposition of the proteid material. As Stutzer himself has pointed out, peptones are very incompletely precipitated by cupric hydroxid. A further objection is to be found in the very slight solubility of the copper salts of some of the simpler amido-acids, especially leucin and glutamic acid; in a less degree the same statement applies to aspartic acid. Even at the temperature of boiling water the copper compounds of these substances are but very sparingly soluble, and if the liquid, after digestion with cupric hydroxid, be filtered cold,[1] the compounds in question will, if present, be almost certainly left on the filter along with the proteid material.

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[1] As directed by the Association of Official Agricultural Chemists, Bulletin No. 46 of the U. S. Department of Agriculture, Division of Chemistry (1895), p. 25.

RELATIONS TO ALCOHOL AS A SOLVENT.

It has been repeatedly proposed to use strong alcohol for the precipitation of the proteids, with a view to their quantitative determination, and this even in cases involving the simultaneous presence of some of the amidic compounds under discussion, such as the flesh bases.[1] But not only do the character and amount of the proteids so precipitated or left insoluble vary with the strength of the alcohol and the quantity of it used, but the further serious objection presents itself that nearly all the simpler amids and amido acids are either insoluble in alcohol or so slightly soluble that it is practically impossible to wash them out satisfactorily from the precipitated or coagulated proteids. A method which is not properly applicable to such important substances as asparagin among vegetable food materials, and kreatin among those of animal origin, manifestly deserves but little consideration.

BEHAVIOR WITH SEVERAL NEW OR LITTLE USED REAGENTS.

A number of miscellaneous experiments were tried with reagents which have either been but occasionally applied to materials of the kind under examination, or have not been so applied at all, so far as published records show.

A weak solution of pure phenol (carbolic acid), trichloracetic acid, formic aldehyde in aqueous solution, and hydrazoic acid (azoimide) were thus tried, but from none of these reagents were results obtained which furnished any ground for a general method of distinguishing the two classes of nitrogenous materials which were being studied.

BEHAVIOR WITH PHOSPHO-TUNGSTIC ACID.

This reagent, the discussion of which I have left to the last, has proved of much more value than any other I have tried, and its application under proper conditions affords, I believe, a fairly satisfactory practical solution of the question I have undertaken to examine. The use of phospho-tungstic acid for the precipitation in general of nitrogenous compounds, alkaloidal, amidic, and proteid, is, of course, well known and often practiced, but some of the special facts on which may be founded its application to the purpose now under discussion are believed to be new, and the particular use made of these points of behavior has not been before described. In connection with the experiments made with phospho-tungstic acid, the results obtainable from a parallel series of experiments with a strong solution of tannic acid were compared, one of these two reagents being found under special circumstances to replace the other with advantage.

The precipitant was employed not as a sodium or other salt, but as the phospho-duodeci-tungstic acid, crystallized in small cubes and dissolved in dilute hydrochloric acid, 25 grams of real HCl to the liter. Solutions of two degrees of strength were prepared, the one containing 50 grams of the solid reagent to the liter, the other 100 grams. In the experiments with tannic acid, solutions in like manner containing 50 and 100 grams, respectively, of a remarkably good sample of the reagent, dissolving readily to a perfectly clear liquid, were made use of.

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[1] See Watts's Dictionary of Chemistry, revised edition. Vol. IV, p. 330, and H W Wiley's Principles and Practice of Agricultural Analysis, Vol. III, p. 453.

It has been assumed by Stutzer and others that the proteid and allied substances are precipitated by phospho-tungstic acid, while the simpler amids and amido acids are not so precipitated. As qualifying this general assumption, it has been stated that some of the proteid derivatives, as the peptones,[1] are incompletely precipitated, and on the other hand that the flesh bases, kreatin, kreatinin, etc., are fully precipitated. The reagent in question has been recommended as the means of separating and determining them.[2]

Account does not seem to have been taken hitherto of the fact that some of the precipitates formed by substances of amidic character with phospho-tungstic acid are to a small extent soluble in water, and that their solubility is much increased by rise of temperature.

CLASSIFICATION OF SUBSTANCES EXAMINED.

It has been found that the various substances on which these experiments have been made fall into three classes, as follows:

(*a*) Those which, even in pretty strong solutions, give no precipitate with phospho-tungstic acid.

(*b*) Those which are precipitated at any rate in strong solutions, the precipitate redissolving with more or less ease on heat being applied to the liquid or on treating the precipitate with hot water, and reappearing on cooling.

(*c*) Those which are precipitated, the precipitate not being sensibly soluble and the supernatant liquid remaining clear on being heated along with the precipitate and subsequently cooled.

Under the first head fall glycocin, alanin, leucin, aspartic acid, asparagin, glutamic acid, tyrosin, and allantoin. In the case of alanin there was a very slight turbidity, not increased by using a saturated solution, suggesting the probability of a trace of some impurity being present.

Under the second head were observed glutamin, a slight precipitate, the solution easily cleared by heating, the turbidity reappearing on cooling; betaine in strong solution, a copious white precipitate, dissolving gradually on addition of more water and heating, the precipitate reappearing on cooling; kreatin, strong precipitate, solution cleared by heating, becoming turbid again on cooling; kreatinin, large precipitate, disappearing on free addition of water and heating, reappearing on cooling; hypoxanthine, strong precipitate, cleared up on heating, reappearing on cooling; and carnine, well-marked precipitate, cleared by moderate addition of water and heating, reappearing on cooling. Urea also, which is not likely to occur among food materials, but possibly needs to be considered in connection with undigested residua, gave a copious white precipitate of crystalline character, cleared by heating, and the precipitate forming anew on cooling. A peptone solution gave an abundant precipitate, becoming clotted by heating and dissolving to a considerable extent, reprecipitating on cooling.

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[1] Dr. W. D. Halliburton in the article "Proteids" in Watts's Dictionary of Chemistry, revised edition, Vol. IV, p. 331. In Gamgee's Text-book of Physiological Chemistry, Vol. II, p. 139, it is stated that peptones are precipitated by phospho-tungstic and phospho-molybdic acids, and that these two reagents furnish the means of separating them. A similar unqualified statement is to be found in the Appendix (by A. Sheridan Lea) to Michael Foster's Text-book of Physiology, p. 45.

[2] Koenig and Boemer—Zeitschrift für analyt. Chemie., 34, 560, adopted in Prof. H. W. Wiley's Principles and Practice of Agricultural Analysis, 3, 454.

Under the third head were found egg albumin, fibrin, casein, legumin, globulin, vitellin, myosin, syntonin, hæmoglobin, albumose, gelatin, and chondrin. In nearly all these cases the precipitate formed was bulky, taking into account the strength of the solution used, and became clotted on heating, shrinking very considerably. In the case of myosin only (in 10 per cent sodium chlorid solution) was there a very slight appearance of turbidity on cooling the solution which had been heated with the precipitate.

USE OF HOT WATER.

As it was evidently important to ascertain with some degree of definiteness how far the precipitates formed by amidic substances of the second of these classes would dissolve in hot water, quantitative experiments were made with those which seemed to be least soluble. In each case the precipitate formed by phospho-tungstic acid in the cold was filtered off, washed with cold water, and dried at ordinary temperature (15° to 20°) over sulphuric acid. Stutzer advises that the phospho-tungstic acid precipitates be washed with dilute sulphuric acid, and Wiley recommends for the same purpose a solution of the precipitates. Of the precipitate formed by betaine, 1 part dissolved in 71 parts of water at 98.2°; of that produced by kreatin,[1] 1 part dissolved in 107 of water at 98.1°; of that produced by kreatinin, 1 part dissolved in 222 of water at 97.9°; of that produced by hypoxanthin, 1 part dissolved in 98 of water at 97.6°; and of that produced by carnin, 1 part required for solution 132 of water at 98.4°.

By the use of phospho-tungstic acid as a precipitant, therefore, followed by washing of the precipitate with hot water, it seems possible to effect a separation of all the simpler amidic substances from all the proteids and proteid-like bodies, except only the peptones. As regards this last group it is stated unreservedly by A. S. Lea,[2] A. Gamgee,[3] and W. D. Halliburton[1] that the peptones are precipitated by tannic acid. The last-named writer says "completely precipitated." In one or two of the writer's own experiments, using tannic acid, an abundant precipitate was formed. This became clotted on heating and the clear supernatant liquid showed some little return of turbidity on cooling. The writer is inclined, however, to attribute this apparent partial re-solution of the precipitate merely to the presence of a little of a proteose formed in the earlier stages of digestion and not afterwards completely removed. Assuming this view to be correct, tannic acid furnishes the reagent needed to dispose of the one case unprovided for by phosphotungstic acid.

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[1] The phospho-tungstic acid precipitate formed by kreatin, white at first, darkened notably on exposure to light, looking after a while like silver chloride which had been in like manner exposed. The experiment on solubility was made with a sample which had been screened from light and was unaltered.

[2] The Chemical Basis of the Animal Body, an appendix to M. Foster's Text-book of Physiology (1893), p. 45.

[3] A Text-book of the Physiological Chemistry of the Animal Body (1893), **2**, 139.

DETAILS OF THE METHOD WITH PHOSPHO-TUNGSTIC ACID.

The method proposed is as given in the following paragraphs. It is stated, for the sake of simplicity, first, as applicable to meat, raw or cooked. The variations required in the examination of other classes of food materials are reserved for notice afterwards.

A carefully selected and accurately weighed sample is to be ground in a glazed porcelain mortar with as much sharp-edged siliceous sand, previously heated to redness with free exposure to air, or with as much hard glass in small, sharp splinters similarly ignited, as shall suffice to thoroughly subdivide the tissue and reduce it to the condition of a smooth pulp. Of this pulp, very carefully mixed, so as to insure uniformity, two aliquot parts are to be taken. In one the total nitrogen is to be determined by the well-known Kjeldahl process with addition of potassium sulphate, as recommended by Gunning, using a rather large proportion of sulphuric acid, so that no previous drying of the sample is needed. The other part is to be digested with cold water, filtered on a nitrogen-free filter,[2] and the residue washed on the filter with water at the same low temperature as long as it gives up soluble matter in sensible amount. Cold water is used to avoid action on and extraction of the gelatinoids. Kreatinin is quite easily dissolved, as is also sarcosine; kreatin with a very fair degree of ease. Xanthin, hypoxanthin, and carnin are less soluble.[3]

The filtrate is then to be slightly acidified with acetic acid, heated to about 90° C., and again filtered from any coagulum produced. A little more sand or pulverized glass may with advantage be stirred in before bringing it onto the filter the second time.

To this second filtrate is to be added an acidified solution of phosphotungstic acid as long as a precipitate continues to form, avoiding any very large excess of the reagent solution. With a moderate amount of sand or pulverized glass added, to prevent the formation of a dense clot, the liquid and precipitate are to be heated to about 90° C, filtered, and the precipitate washed thoroughly on the filter with water at about the same temperature. This third filtration may be carried out on the same filter already used for the second, but as a general rule it will be found better to use a new filter, thus avoiding possible delay due to partial drying of the previously used one and subsequent clogging of its pores.

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[1] Watt's Dictionary of Chemistry, revised edition, 1894, **4**, 331.

[2] The ease with which filtration may be effected is much increased by the presence of the sand or crushed glass.

[3] Hypoxanthine, 1 part in 300 of water. The solubility of carnine does not seem to have been recorded till now. The writer has found it to be 1 part in 312 of water at 15.3° C.

Assuming now that nitrogen is present in the sample under examination only in the two forms of proteids and simpler amidic compounds, the three (or two) filters used and their contents are to be submitted to the Gunning-Kjeldahl process for the determination of proteid nitrogen. By subtraction of this from the total nitrogen previously determined the amount of this element present in the simpler amidic compounds will be obtained.

In cases involving the presence of ammonia or its salts, nitrates, or alkaloids, the nitrogen occurring in these forms must, of course, also be deducted from the total nitrogen before recording the residue as nitrogen of the simpler amids and amido-acids. In like manner a separation of lecithin, when present, may be effected by the use of ether as a solvent,[1] a determination of phosphorus made the basis of a calculation of lecithin nitrogen, and this in turn subtracted from the total nitrogen found.

When peptones are present, these are to be precipitated by tannic acid from the solution which has been acidified with acetic acid and heated. After this has completely cooled down, and before adding phospho-tungstic acid, the filter on which the tannic-acid precipitate is collected and washed with cold water is, with its contents, to be submitted to the modified Kjeldahl process, and the nitrogen obtained counted as part of the proteid nitrogen.

The several filters and precipitates from which the proteid nitrogen is obtained may either be treated separately by the Kjeldahl process or, preferably, may all be brought together and submitted to this process in a single operation. If the latter course be pursued, it will be well to introduce each filter with its contents as soon as washed into the strong sulphuric acid, so as to avoid any possible decomposition and loss of nitrogen as ammonia until all the filters have been brought together and the moist combustion process can be proceeded with.

When proteoses are present it may be well to make a check determination of their amount by saturation of the aqueous solution, after acidification with acetic acid, heating and subsequent cooling, with zinc sulphate,[2] and determining nitrogen in the precipitate so formed by means of the Kjeldahl process.

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[1] Extraction with the ether alone will remove only a portion of the lecithins. A mixture of ether and alcohol should follow the ether in order to secure a complete extraction.

[2] As suggested by Boemer, Zeitschrift für analyt. Chemie, 1895, **34**, 562.

When gelatinoids are present, as may be the case with soups, stews, and meat extracts, hot water may be used at once for solution or washing the original material, and this with the advantage of facilitating the extraction of the less soluble simpler amids and amido-acids. These are, as a rule, more easily dissolved in the presence of a little free acid; hence acidification at an early stage of the treatment is advantageous. In a case in which tyrosin might be present, as in some vegetable materials, and possibly among unabsorbed residua of food, the use of hot water and the presence of free acid would greatly increase the solubility of this substance.

In food of vegetable origin where much starch is present it will be better to avoid the use of hot water at first, so that the solution may not be loaded with viscid material, rendering filtration difficult.

In all cases in which the food material to be examined is already fluid from the presence of water—as, for instance, soup, milk, and the like—filtration will of course at once be resorted to, being almost always much facilitated by the addition of sand or pulverized glass, and only such further quantity of water will be used as is required for washing the undissolved matter left upon the filter.

In the presence of fat in large quantity, it may be well first to remove this, or most of it, by extraction with ether. The simpler amidic substances are, as a rule, insoluble in ether, but by way of precaution the ethereal solution of fats might be shaken up two or three times with acidified water, and the watery fluid evaporated and tested for nitrogen.

In regard to the method of reporting results, the most important point is the separate statement of the amount of nitrogen present in the form of proteids and their more closely related congeners and in the form of the simpler amids and amido-acids. But in attempting to calculate from the nitrogen found under these heads the actual amount of the proximate nitrogenous constituents of the food material examined, the question arises, What factor should be used by which to multiply the nitrogen found in each case?

FACTORS FOR CALCULATION OF TOTAL NITROGEN.

The error noticed by Professor Wiley[1] as involved in the multiplication of the total nitrogen of a sample of meat by 6.25, and the assumption that the product represents the true quantity of nitrogenous matter, is not restricted to the use of the same factor for the proteids and flesh bases. While the multiplier should be a much smaller one for the latter, it also confounds under a single head these two classes of material, unquestionably possessing very different nutritive values.

It is evident that for each substance examined, or at any rate for each class of generally similar food materials, there should be made a qualitative investigation of the simpler amidic constituents present, and if possible a roughly approximate estimate of the proportions in which they severally occur; also it is clear that the factor to be used in calculating the nitrogenous constituents to be reported under each analysis should be decided by such preliminary investigation. In the light of present knowledge of this kind the writer is inclined to suggest the following numbers:

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[1] Principles and Practice of Agricultural Analysis (1897), 3, 551.

For proteids and allied substances, multiply nitrogen found by 6.25, as usual at present.

For flesh bases and simpler amids of animal origin in food materials, multiply by 3.05.

For simpler amids and amido-acids of vegetable origin in food materials, multiply by 5.15.

For mixed amidic constituents of unabsorbed solid residua in digestion experiments, multiply by 9.45.

As a matter of general practice, in all statements of the results of nutrition experiments the rule should be invariably observed to give the actual amounts of nitrogen obtained by analysis, whatever calculated conclusions be afterwards deduced therefrom; so that, with further knowledge of the nature of the proximate nitrogenous constituents present, the factor used in calculation may be changed, if such change seems to be called for, while the original experimental work still retains its value.

In concluding this report the writer wishes to express the hope that the method suggested, which seems to carry with it some improvement upon present practice and in a fairly simple and easily applied form, may be tried with yet other amids and proteids than those experimented on by him, and that any special difficulties which may be encountered with particular articles of food may be investigated. Especially is it desirable that the variations be studied which may prove to be necessary in dealing with vegetable instead of animal materials. The latter have been chiefly kept in view, in accordance with the instructions of the letter of authorization under which this investigation has been conducted.

SEPARATION OF PROTEID BODIES FROM THE FLESH BASES BY MEANS OF CHLORIN AND BROMIN.

By H. W. WILEY.

In dry, finely-ground animal matters from which the fats have been thoroughly extracted with ether, it is possible to effect an easy separation of the nitrogenous bodies into three groups. These groups, for purposes of dietetic study, are sufficiently distinct to afford a safe basis of valuation of the different nitrogenous constituents. The process which has been adopted in the laboratory of the Division of Chemistry, Department of Agriculture, for this separation is given in detail here.

DETAILS OF METHOD.

In the dry, fat-free, finely-ground animal substance the nitrogenous bodies soluble in water may be separated by first thoroughly exhausting the material with cold or lukewarm water, and afterwards with water near the boiling temperature. By this method the water-soluble constituents of the nitrogenous substances are thoroughly removed. Having determined the total percentage of nitrogen in the whole sample, the residual insoluble nitrogen is determined in the residue left after extraction. This percentage multiplied by 6.25 gives the total quantity of insoluble proteid matter contained in the animal material. In the filtrate the soluble proteid matter which has been dissolved by the water may be completely thrown out of solution by treatment with bromin in the manner about to be described.

About one-gram portions of the dry animal material are washed with ether by decantation, using from 50 to 100 cc of ether for each sample, and decanting the ether through filters which are afterwards used to receive the portion of the sample insoluble in hot water. After allowing the ether to evaporate, the samples are treated first with cold and then with hot water, this washing also being by decantation, the total amount of water used being from 300 to 400 cc. The undissolved residues are brought on to the filter with the last portions of water. The nitrogen in the residues on the filters is determined by the Gunning method.

The filtrate from the insoluble portions of the meat is received in Kjeldahl flasks and used for the separation of the soluble proteid nitrogen by bromin. The filtrate is first acidulated with two or three drops of strong hydrochloric acid and then about 2 cc of liquid bromin are added and the contents of the flask vigorously shaken. If the bromin be all taken up more is added until finally a globule of ½ cc of liquid bromin is left undissolved and the supernatant liquid is thoroughly saturated with bromin. The mixture is then allowed to stand overnight, by which time the precipitate will have settled. The supernatant liquor is passed through the filter and the precipitate in the flask washed by decantation with water, the globule of undissolved bromin serving to saturate the wash water so that it is unnecessary to use additional bromin water for the washing. The filter containing the precipitate is returned to the same flask in which the precipitation has taken place and the nitrogen therein determined by the Gunning method. The sum of the nitrogen in the part insoluble in water and the part precipitated by bromin is subtracted from the total nitrogen determined on the original sample, and the difference gives the total nitrogen in the flesh bases.

FACTORS FOR CALCULATION OF TOTAL NITROGEN.

The factors used for calculating the total nitrogenous bodiès are as follows:

For the part insoluble in water, N × 6.25.

For the part soluble in water and precipitated by bromin, N × 6.25.

For the flesh bases, N × 3.12.

This method is based upon investigations reported by Rideal and Stewart[1] last year.

These writers recall some of the experiments made in 1876, in which it was shown that a current of chlorin gas, conducted through an aqueous solution of proteid matters, produces a precipitate which is of a quite constant composition, and one which can be collected, dried in vacuo, and weighed. They describe particularly the use of this reagent in precipitating gelatin prepared from the high-grade commercial article. They show that the total quantity of gelatin can be accounted for from the weight of the precipitate by multiplying the weight of the precipitate obtained by the factor 0.78. The authors also point out the possibility of using bromin for chlorin for the precipitation, and state that the studies of the use of bromin are under way. They call attention to the fact that as early as 1840 chlorin had been used by Mulder for the precipitation of soluble proteids, and refer to a paper of his published in Berzelius' Jahresbericht, volume 19, page 734, in which he states results on precipitation quite similar to those secured by Rideal and Stewart.

At the close of their paper Rideal and Stewart mention the work in this direction of De Vrij, Ann. Pharm. **61**, 248; Thénard, Mém. d'Arcueil, **2**, 38; Mulder, Bulletin en Néerlande, 1839, 153, and Berzelius' Jahresbericht, **19**, 729, on the same subject.

Allen and Searle,[2] acting on the suggestion of Rideal and Stewart, worked out the bromin method by applying it to various soluble proteids, including the whole range from albumin to peptone. In the application of this test to commercial gelatin the following process was employed.

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[1] The Analyst, 1897, **22**, 228 et seq.

[2] The Analyst, 1897, **22**, 258-263.

Fifty grams of commercial gelatin were dissolved in warm water and the solution diluted to half a liter. In 10 cc of this solution, corresponding to 1 gram of the gelatin, the nitrogen is determined directly by the Gunning-Kjeldahl process. Another portion of 10 cc is treated with an excess of bromin in the following manner.

The solution is first brought to a volume of 100 cc with water and placed in a conical beaker with a sufficient quantity of hydrochloric acid to produce distinct acid reaction. A saturated solution of bromin water is added in considerable excess, and the liquid stirred vigorously for some time. The precipitate which separates is flocculent when first formed, but becomes more viscous after stirring and adheres for the most part to the sides of the beaker, which, with its contents, is allowed to stand for about half an hour, or until all the precipitate is settled. The supernatant liquor is decanted through an asbestus filter. The precipitate adhering to the beaker is washed several times with cold, distilled water and the washings poured through the filter. Occasionally, when most of the free bromin is washed out of the precipitate, the liquid does not filter clear. It is therefore advisable to keep the washings separated from the filtrate, and, if necessary, wash with sodium-sulphate solution or with bromin water. The nitrogen in the precipitate is determined by the Gunning-Kjeldahl process as follows:

The precipitate which has been collected on the asbestus filter, together with the asbestus, is returned to the beaker in which the precipitation took place. Twenty cubic centimeters of strong sulphuric acid are added, the beaker covered with a watch glass and placed on a wire gauze over a lamp. When frothing has ceased, about 10 grams of powdered potassium sulphate are added and the liquid boiled until colorless. After cooling it is distilled with water and the ammonia distilled off and determined in the usual way. The percentage of nitrogen found, when multiplied by the factor 6.33, or in the case of gelatin by 5.5, gives the amount of proteid matter precipitated by bromin. In the commercial gelatin above mentioned the nitrogen content was found to be 14.1 and 14 per cent, respectively, on two determinations. Solutions of kreatinin, asparagin, and aspartic acid were found to yield no precipitates with bromin, but bromin was found to precipitate all albumin, acid albumin, and all peptones formed by the digestion of albumin with pepsin.

APPLICATION TO COMMERCIAL MEAT EXTRACTS.

On applying the bromin method to commercial meat extracts the following results were obtained. The solutions of the Bovril preparations were not previously filtered, and therefore the figures contain the nitrogen and the fiber present.

Nitrogen in commercial meat extracts.

Substance.	Nitrogen in precipitate by bromin.	Proteids (N x 6.25).
	Per cent.	*Per cent.*
Liebig Company's extract	1.41	8.92
Seasoned bovril	1.94	12.28
Bovril for invalids	2.64	16.71

Koenig and Boemer have shown that the proteid nitrogen in meat extracts is generally much overestimated. They found a total of 1.17 per cent of proteid nitrogen in the Liebig Company's extract, which is equivalent to 7.41 per cent of total proteids, mostly albumose. The fact that bromin completely precipitates all proteid and gelatinoid matters in solution, affords a convenient means of solving certain problems which have hitherto presented considerable difficulty. For instance, in a solution which has been subjected to digestion it may be possible to precipitate all the unchanged proteids by saturation with zinc sulphate. The peptones which have been formed during digestion remain in solution and can be separated by filtration. In the filtrate the peptones can be completely precipitated by bromin, and thus the total quantity of these bodies formed during digestion can be accurately determined.

Allen and Searle applied this method to an examination of the Liebig Company's extract, 5 grams of which were dissolved in 100 cc of water and the solution saturated with zinc sulphate. After filtering, bromin water was added to the filtrate and a precipitate produced which redissolved on diluting with water and the addition of hydrochloric acid. When the filtrate from the saturated zinc sulphate was previously diluted with water and acidulated, no precipitate was formed on the addition of bromin. This reaction shows that no considerable quantities of real peptones exist in Liebig's extract.

Since this bulletin was prepared for the press, an extensive article on the halogen derivatives of albumin has been published by F. Blum and W. Vaubel[1] of Frankfurt, Germany.

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[1] Ueber Halogeneiweissderivate, Journal für praktische Chemie, 1897, **56**, 393–6, and 1898, **57**, 365–396.

BULLETIN No. 55.

U. S. DEPARTMENT OF AGRICULTURE.
DIVISION OF CHEMISTRY.

THE FERTILIZING VALUE OF STREET SWEEPINGS.

AN INVESTIGATION MADE UNDER THE DIRECTION OF

H. W. WILEY,
CHIEF CHEMIST,

BY

ERVIN E. EWELL,
FIRST ASSISTANT CHEMIST.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1898.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF CHEMISTRY,
Washington, D. C., June 21, 1897.

SIR: I have the honor to submit for your inspection and approval the accompanying manuscript of the report of the investigation of the fertilizing value of street sweepings, which you authorized to be undertaken by this division on May 26, 1897. It is believed that the information resulting from this investigation will be of assistance to city officials who are seeking to extend the use of street sweepings in agriculture, and also be of benefit to farmers and gardeners to whom such materials may be available. I recommend that this report be published as a bulletin of this division, and that it be circulated as an aid in improving the methods employed for the collection of street sweepings and in extending their use for the maintenance of the productiveness of American farms and gardens.

Respectfully,

ERVIN E. EWELL,
Acting Chief of Division.

HON. JAMES WILSON,
Secretary.

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THE FERTILIZING VALUE OF STREET SWEEPINGS.

DATA IN REGARD TO THE QUANTITY AND METHODS OF DISPOSITION OF STREET SWEEPINGS IN THE UNITED STATES.

In accordance with an authorization of the Secretary of Agriculture, dated May 26, 1897, the Division of Chemistry sent circular letters of inquiry to the officials in charge of street-cleaning departments in the 354 cities and towns of the United States having 10,000 or more inhabitants. More or less complete data in regard to the disposal of the street sweepings of 204 cities and towns were thus obtained. Estimates of the number of tons of sweepings collected annually in 81 of these cities were received. In compiling the data in regard to disposition, the methods of disposal have been divided into three classes: Utilization for fertilization, utilization for filling low land, and dumping wherever most convenient without any regard to the possible value of the materials.

In the first class are included all cities which succeed in disposing of some portion of their street sweepings for agricultural purposes, including many cases in which only a very small percentage of the total amount of sweepings is so used. The second class includes all cases in which no attempt is made to turn to account the fertilizing value of the material, but in which some part of the material is used for filling in low land, for reclaiming marsh land, etc. The third class includes those cities where the material is dumped in streams or other bodies of water, or on land, without any systematic attempt at utilization.

A summary of the data obtained is presented in the following table, in which the figures for population are taken from the reports of the Eleventh Census:

Data in regard to the amount of street sweepings collected in the cities of the United States, and the methods in use for their disposition.

	Cities reporting—				Cities which furnished no report.	Total for all cities to which inquiries were sent.
	Use of street sweepings for fertilization.	Use of street sweepings for filling.	No system of utilization.	Total.		
Data in regard to methods of disposition.						
Number of cities having—						
10,000 to 14,999 inhabitants	15	24	32	71	67	138
15,000 to 24,999 inhabitants	17	20	19	56	36	93
25,000 to 49,999 inhabitants	13	16	5	34	32	66
50,000 to 99,999 inhabitants	10	4	8	22	8	30
100,000 or more	5	10	6	21	7	28
Total number of cities	60	74	70	204	150	354
Per cent of total number of cities to which inquiries were sent	16.95	20.90	19.77	57.62	42.38	100
Urban population represented:						
Number of inhabitants	2,949,569	5,157,764	3,887,182	11,994,515	5,442,882	17,437,397
Per cent of total population of the 354 cities	16.92	29.58	22.29	68.79	31.21	100
Average population of the cities of the different groups	49,160	69,700	55,531	58,796	36,285	49,258
Data in regard to the quantity of street sweepings collected annually.						
Number of cities reporting tonnage, divided according to method of disposition:						
Number of cities having—						
10,000 to 14,999 inhabitants	7	6	8	21	117	138
15,000 to 24,999 inhabitants	11	7	4	22	70	92
25,000 to 49,999 inhabitants	6	9	1	16	50	66
50,000 to 99,999 inhabitants	4	3	2	9	21	30
100,000 or more	3	6	4	13	15	28
Total number of cities	31	31	19	81	273	354
Per cent of the total number of cities to which inquiries were sent	8.76	8.76	5.36	22.88	77.12	100
Urban population represented:						
Number of inhabitants	1,672,750	3,459,028	1,173,542	6,305,320	11,132,077	17,437,397
Per cent of the total population of the 354 cities	9.59	19.84	6.73	36.16	63.84	100
Average population of the cities of the different groups	53,960	111,581	61,765	77,843	40,777	49,258
Total number of tons collected annually	174,931	673,791	216,235	1,064,957	....	....
Number of tons collected annually, per 1,000 inhabitants	104.6	194.8	184.3	168.9	....	....

From an examination of these data it appears that 68.79 per cent of the people in the United States living in urban communities having 10,000 or more inhabitants were represented in the reports in regard to the disposal of street sweepings, while no reports were received from cities representing 31.21 per cent of our urban population. Of the 354 cities to whom inquiries were sent 57.62 per cent reported methods of disposition, showing that among the cities reporting there was a preponderance of those above the average size. This is also apparent from the figures given in the table for the average population of the cities in the different groups.

By the reports received it is shown that the cities containing 16.92 per cent of our urban population make more or less effort to utilize the fertilizing value of their sweepings. If the same proportion prevails in the case of the cities from which no reports were received this figure should be increased to 24.6 per cent. In general terms it may be stated that the cities representing one-fourth of the urban population of the country make an effort to utilize the fertilizing value of some portion of their street sweepings.

The data reported in regard to the quantity of street sweepings collected annually were still less complete than the data in regard to methods of disposition; only 36.16 per cent of our urban population was represented in the reports in regard to the quantity of street sweepings collected annually. For the cities reporting, the average quantity collected annually is 168.9 tons per 1,000 inhabitants. Assuming this to be a true average for all of the cities of the United States, the total quantity of street sweepings annually collected may be estimated at not far from 3,000,000 tons.

The data contained in the reports relating to the cost of street cleaning in the various cities of the country were not sufficiently complete and satisfactory to justify their tabulation. In many cities the amount of money used for this purpose can not be separated from amounts used for other purposes. In other cases mere estimates were given for the cost per ton. The dearth of records of this sort in many cities renders the compiling of data impossible, and in many other cases it is extremely difficult to obtain complete statistical data without sending an agent to each city. While this would be very expensive in connection with an investigation of this kind, it might be very economically and satisfactorily done in connection with our regular census enumeration. It was necessary to send a second request to many of the cities before some of the data which we have presented were obtained. As appears from the table nearly one third of the cities did not respond to either inquiry.

CIRCUMSTANCES WHICH DETERMINE THE FERTILIZING VALUE OF STREET SWEEPINGS.

The fertilizing value of street sweepings varies greatly with the nature of the pavements, being practically nothing in the case of material taken from macadamized roads, and approaching that of good stable manure in the case of that collected on the hand-swept and well-paved streets of crowded cities. The regulations in different cities governing the nature of substances which may be thrown into the alleys and streets, and thus find their way into the material collected by the sweepers, vary so greatly that there is consequently a corresponding difference in the cost of sorting and preparing the material for spreading on the land. It is believed that the rapidly increasing sentiment in favor of the careful separation and systematic utilization of all forms of city wastes will tend to remove this difficulty and thus increase the value of sweepings, particularly of those collected in alleys, where the percentage of miscellaneous rubbish is now often very great.

In autumn the quantity and, in many cases, the quality of the street cleaner's product is greatly increased by the falling leaves.

ANALYSES OF STREET AND ALLEY SWEEPINGS.

The range of composition of the sweepings collected by various methods on well paved streets and alleys at different seasons of the year is quite well exhibited in the following table of analyses of typical samples of sweepings collected on the streets of Washington, D. C. The analyses were made in the laboratory of this Division; the nitrogen determinations, by Mr. T. C. Trescot; the potash determinations, by Mr. George E. Patrick; and the determinations of moisture, ash, and phosphoric acid, by Mr. C. C. Moore. The determination of the phosphoric acid and potash contained in the organic part of street sweepings, without including that contained in the soil which is mixed with them, is not a simple problem. For the determination of phosphoric acid the method of the Association of Official Agricultural Chemists was used, the solution being prepared according to method A_2 (see p. 12 of Bulletin 46 of this Division); for the potash determinations the official method was followed, with the exception of the omission of the sulphuric acid used in burning off the organic matter; the official Kjeldahl method was used for the determination of nitrogen.

Analyses of street and alley sweepings, etc., collected in Washington, D. C.

(Analytical data are stated in percentages of the original material in its moist condition.)

Serial No.	Dates on which samples were taken.	Description of samples.	Moisture.	Ash.	Organic matter.	Nitrogen.	Phosphoric acid (P_2O_5).	Potash (K_2O).
	1898.		*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
17014	Feb. 8	Sweepings collected by hand on Pennsylvania avenue (asphalt pavement) and sold to a Virginia farmer for 25 cents per 2-horse load. The sample was taken from a pile which had lain on the dump at Twenty-first and B streets SW. for not more than 2 days	......	......	......	0.38	......	......
17015	Feb. 8	Machine-collected sweepings, which were practically all leaves, taken from the streets in various parts of the city in the autumn of 1897. The sample was taken from the undecayed, dry leaves on the surface of a pile on the dump at Twenty-first and B streets SW. The analysis was made of the air-dry material	......	......	......	1.18	......	......
17016	Feb. 8	The same as No. 17015, except that the sample was taken from the wet, interior, decayed part of the pile	......	......	......	.32	......	......
17019	Feb. 11	Street sweepings taken from stone-block pavement on Fourteenth street, between B and C streets SW. First cleaning after the melting of the snow. Street was very dirty	......	......	......	.27	......	......

Analyses of street and alley sweepings, etc., collected in Washington, D. C.—Continued.

Serial No.	Dates on which samples were taken.	Description of samples.	Moisture.	Ash.	Organic matter.	Nitrogen.	Phosphoric acid (P_2O_5).	Potash (K_2O).
	1898.		*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
17020	Feb. 11	Street sweepings taken from asphalt pavement on B street SW., between Thirteen-and-a-half and Fourteenth streets SW. First cleaning after the melting of the snow. Street was very dirty	......	......	......	.25	......	......
17034	Feb. 23	Taken from stone-block pavement on B street NW., between Fourteenth and Fifteenth streets NW., where snow, taken from other parts of the city, had been dumped and allowed to melt	......	......	......	.17	......	......
17214	May 13	Street sweepings from the dump at Fifteenth and C streets SW. The sample was a composite one, made from several piles, which were 6 to 8 months old	45.7	38.0	16.3	.30	0.08	0.09
17215	May 13	Street sweepings from the dump at Fifteenth and C streets SW. The sample was taken from a pile which was largely composed of leaves, which had lain on the dump for 6 to 8 months	37.5	49.3	13.2	.25	.01	.09
17216	May 13	Street sweepings from the dump at Fifteenth and C streets SW. The sample was taken from a pile which was mostly manure, and which had lain on the dump for 6 to 8 months	28.7	56.8	14.5	.32	.08	.11
17218	May 14	Machine-collected sweepings, taken from the dump at Twenty-first and B streets SW. The material had lain on the dump but a few days. It contained a very large proportion of sand	6.2	76.4	17.4	.32	.04	.18
17219	May 14	The same as No. 17218, except that the material appeared to consist principally of manure	16.4	48.1	35.5	.73	.16	.31
17220	May 14	Fresh, hand-swept sweepings (from asphalt pavement) taken from the dump at Twenty-first and B streets SW. The material was largely composed of manure	39.5	31.6	28.9	.55	.10	.37
17221	May 14	Material from "sewer drops," taken from the dump at Twenty-first and B streets SW.	40.5	36.2	23.3	.56	.08	.16
17222	May 14	Of the same origin as No. 17221, but the material had a decidedly different appearance (nearly all sand)	29.5	54.0	16.5	.31	.10	.06
17223	May 14	Alley sweepings, 3 to 4 weeks old, taken at the dump at Half street SE., between N and O streets. A large percentage of coarse rubbish was separated from the sample before it was prepared for analysis	16.4	66.6	17.0	.47	.02	.12
17224	May 14	Decayed street sweepings, taken from the face of the bluff at the dump at Twenty-fourth and N streets NW. A composite sample made up of portions taken from several parts of the dump	36.6	49.6	13.8	.41	.08	.13
17225	May 14	The same as No. 17224, except that the sample was taken from a single place, which appeared to be especially rich	30.0	59.7	10.2	.39	.06	.17
17226	May 14	The same as No. 17220, except that the material had lain on the dump for 2 to 4 weeks	52.3	18.0	29.7	.65	.10	.50
17227	May 14	A sample of fish refuse, taken from the dump at Half street SE., between N and O streets	28.1	18.6	53.3	9.15	6.79	.03

There seems to be a dearth of recent literature on the subject of the fertilizing value of street sweepings. J. H. Vogel published two short papers[1] on this subject, in which he included an analysis of sweepings taken from the asphalt-paved streets of Berlin. This material had the following composition:

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[1] Mitteilungen der deutschen Landwirtschafts-Gesellschaft, 1892, 7, 89-90, and Deutsche landwirtschaftliche Presse, 1892, 19, 1056; Experiment Station Record, 4, 222 and 518.

	Per cent.
Moisture	39.89
Ash	37.67
Organic matter	22.44
Total nitrogen	.479
Ammoniacal nitrogen	.004
Total phosphoric acid (P_2O_5)	.452
Potash (K_2O)	.370
Lime (CaO)	1.891
Magnesia	.347

A sample representing the accumulation for four weeks of the sweepings from one of the streets of Trenton, N. J., was analyzed in the laboratory of the Agricultural Experiment Station of that State, with the following results:[1]

	Per cent.
Nitrogen	0.18
Phosphoric acid (P_2O_5)	.30
Potash (K_2O)	.19

The station valued this material at 90 cents per ton.

FIELD TESTS OF THE FERTILIZING VALUE OF STREET SWEEPINGS.

We have endeavored to supplement the analytical data just presented with the results of practical tests made by farmers to determine the value of street sweepings as a source of plant food for field and garden crops, and as a source of the humus which is so necessary to a good mechanical condition of many soils. Inquiries sent to farmers and gardeners, whose addresses were furnished by the officials in charge of the street-cleaning departments in various parts of the country, brought a number of letters containing much information on the subject, and, as the following quotations will show, convincing evidence that well-selected and judiciously used street sweepings possess considerable manurial value. The letters describe some of the more successful methods in use for the treatment of street sweepings and for applying them to the soil. It will be noted that of sixteen letters only four report unfavorable results.

EXTRACTS FROM LETTERS FROM FARMERS AND GARDENERS WHO HAVE USED STREET SWEEPINGS FOR THE FERTILIZATION OF FIELD AND GARDEN CROPS.

ATLANTA, GA., *September 7, 1897.*

I have used street sweepings from Atlanta on my little farm with very good results. I find a ton of these sweepings equal to about half ton of housed stable manure of about two-thirds cow and one-third horse manure, provided the sweepings are gathered in the spring, fall, and winter months from clean pavements. The sweepings gathered in the hot summer months, taken from hot pavements with a hot sun, lose their fertile qualities in a great degree. As to garbage and sewage, I never used any as fertilizer, except when small quantities of garbage would get mixed with the sweepings. I have used the sweepings for three years, for corn, oats, wheat, rye, and potatoes, broadcasting about twenty tons to the acre on semiclay and sandy lands. My lands have been greatly improved, more than doubling their yield. On a large proportion of my land I follow the wheat, rye, and oats with a second crop (of corn) the same season, without additional fertilizer. * * *

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[1] Report of the New Jersey Agricultural Experiment Station for 1895, page 92; Experiment Station Record, 8, 877.

The cost will approximate about 75 cents per ton. I have no trouble with tin cans, and not much with paper or other rubbish.

J. L. McCollum.

New Haven, Conn., *September 7, 1897.*

Have used street sweepings, with fair results, as a fertilizer.

A. N. Farnham.

Atlanta, Ga., *September 8, 1897.*

I have had experience only with street sweepings which comprise almost exclusively the droppings of horses on the streets of Atlanta paved with asphalt and Belgian blocks. I first used a half carload, or, in other words, twelve 2-horse wagon loads of street sweepings, on about an acre and a third (nine loads per acre), at my place near Marietta, 20 miles above this city. The remainder of the 5-acre tract, with this acre and a third, was planted in corn. In October I gathered four and a half 2-horse loads of corn—in other words, about 45 bushels on the acre and a third; and the other three and two-thirds acres only produced three and a half wagon loads—in other words, the very small yield of 35 bushels. It is fair to state, however, that the acre and a third had been planted in pease the year before, whereas the three and two-thirds acres had been left in Bermuda grass, which had been its condition for some years. There was nothing more than a general lesson taught by that experience.

Last fall, however, I broadcast the street sweepings at the rate of about thirty or more 2-horse wagon loads to the acre and planted the land in winter grazing oats. On a portion of the same tract immediately adjoining this I placed no street sweepings at all, although I had pease planted on the land last year. When I thrashed my oats, early in June, the tract upon which the street sweepings had been broadcast produced within a slight fraction of 50 bushels per acre, whereas on that which had no street sweepings I produced only 7 bushels per acre—an overwhelming proof of the value of street sweepings as a fertilizer.

I also have a lot of corn this year, fertilized with street sweepings, which has been described by a number of competent witnesses as the finest upland corn they have ever seen. It is proper, however, to say that, in addition to broadcasting 50 or more loads of street sweepings per acre on this corn land, I also last December plowed the land with a turning plow, which went down about 11 inches, and followed this with a scooter 6 inches broad as a subsoil plow, which went an average of 7 inches deeper, thus making the average depth of the plowing 18 inches. I believe that this very deep plowing helped the corn as much as any other factor by reason of the storing up of moisture during the winter, upon which the corn plant fed during the spring drought of forty-three days, within which period the corn of every neighbor I have turned yellow, while mine maintained a dark, green, healthy color.

I also fertilized a piece of ground liberally with street sweepings and planted it in sorghum millet, and have what is estimated a phenomenal yield.

Furthermore, I broadcast the street sweepings heavily, and after plowing in I broadcast pease, and have the statement of the State commissioner of agriculture, Col. R. T. Nesbitt, that it is the finest crop of pease he has ever seen in Georgia. They are very thick, and will average 30 inches or more in height.

The fairest test, however, was that of the oats shown in the early part of this letter. These materials cost me no more than 40 cents per ton.

I have had but little trouble with tin cans and other rubbish mixed with the material. Paper I regard as an advantage, because, like oak leaves, it serves to retain the moisture in the ground. I have never used garbage ashes or garbage tankage.

JOS. M. BROWN.

MUNCIE, IND, *September 10, 1897.*

I have used the street scrapings from the paved streets of Muncie for two years. There are 47 squares, or about 15,000 feet (linear), of paved (sheet asphalt) streets, and we collected from 1½ to 2 tons per day of scrapings. About one-half of the scrapings was scattered direct upon the land; the other dumped off in a large pile—it does not heat or fire-fang. Most of that scattered direct was upon an old timothy sod, thin clay land, and shows no decided results on the present crop of corn, owing to the extremely dry season. That portion that was dumped into a heap I found rotted much quicker and more thoroughly than stable manure with bedding in it. I have used the rotted sweepings upon clay ground for late cabbage and sweet corn, and upon black loam (no sand) for onions and melons.

We put on a heavy coat (3 to 6 inches) before plowing, then thoroughly worked it through with a spring-tooth harrow.

The result was a rank growth of both cabbage and corn. Many a head of cabbage was as large as a half-bushel measure, but soft. None of the cabbage hardened up as it should. The corn did not ear well. For onions and melons it did better than for the other crops.

I used no other fertilizer.

The cost of the manure was the expense of keeping the team and wagons. The city paid for driver. Paper and anything that would rot we put on the ground.

Tin cans, stones, brickbats, wire, and barrel staves were our worst nuisances, and were separated as loaded and unloaded.

STANLEY HATHAWAY.

SEDALIA, MO., *September 9, 1897.*

I have had some experience in regard to the value of the various kinds of offal that accumulate and have to be taken from cities. I have been in the business for about fourteen years, and own a small piece of ground about 4 miles from the city. Street sweepings I regard as worth nothing, from the fact that it is tramped and ground until it is lifeless before it is put upon the ground where it can be plowed under. It will do to fill holes or ditches, the same as straw, and that is all. The garbage from alleys is worth a great deal more, such as falls behind restaurants, hotels, saloons, stables; all are good fertilizers. Tin cans or old bone are good for orchards or grapevines or other fruits, such as berries. Dead animals, no matter what kind, should be buried just a few inches deep, so they do not dry up too quickly and give the earth a chance to absorb the fertilizing substances of the carcass. Horses, mules, cows, or any large animal should be cut in pieces and not placed in one pit. These are good for land that is not yet worn out. But if I wanted to redeem a piece of ground that is considered worn entirely out and make a garden of it, give me that which comes from cleaning privies. Cover the ground with the material and then subsoil it; then repeat the same next year. By the third year your ground will raise potatoes, onions, beets, radishes, beans of any kind, tomatoes, corn, and such, as any huckster or farmer would wish to raise. It should be remembered that subsoiling is one of the main things in all cases where fertilizers of this kind are used. The offal from chicken houses where chickens are dressed or from slaughterhouses is excellent, but the ground must be subsoiled.

W. L. MITCHELL.

BIDDEFORD, ME., *September 29, 1897.*

As to the fertilizing value of street sweepings, I have to say that I have used such materials but one season on old ground, with small results. Cost of material, that of hauling and applying, as the city has furnished same free to all who wish.

JEREMIAH G. SHAW.

ARNOLDS MILLS, R. I., *September 16, 1897.*

I am at the Diamond Hill Reservoir farm of the Pawtucket Waterworks, consisting of about 500 acres of land. I have used street sweepings for four years and find them better than stable or horse manure, for the reason that they contain no straw and are ready for use at any time. The sweepings I get cost nothing except cartage from Pawtucket. When the city sells any the price is $2 per cord. I have used sweepings for corn and raised 90 bushels per acre. The first year I put on 8 cords to the acre, scattered broadcast and plowed in. The yield was 60 bushels per acre. The season was not a good one for corn. I have used sweepings for oats for fodder and obtained 4 tons per acre.

I use 20 cords a year for grass. The material should be plowed in, as it dries when spread on the surface. The yield of grass was 2 to 3 tons per acre. This manure is swept up with a hand broom, so there are no tin cans or rubbish in it. I do not use any other fertilizer besides the sweepings, and have no trouble in raising any crop I wish.

SAMUEL DARLING.

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620 N STREET, SACRAMENTO, CAL., *October 1, 1897.*

I am now putting on my land the sweepings of the asphalt streets of Sacramento, which gives me about three large 2-horse loads per day. The contractor dumps it in a certain place, and I give him $5 per month for it. There is no straw in it, very little paper, and no tin cans or rubbish, as another contractor picks up the rubbish, ashes, cans, straw, weeds, bottles, shoes, etc., and deposits them in another place. I have a good deal of faith in sweepings, as they seem to be in a proper condition for the roots to take hold of. I put the sweepings direct on the hop hills, without further pulverizing or working over. Some tell me I should compost them by working over and wetting them, as we have no summer showers in this section, our rainy season beginning in October. As we have, off and on, four or five months of rainy weather, and in January and February I begin to plow the hops, I thought it would get in good condition for plant use without working and wetting.

Our white labor costs about $1 a day and board. Japanese or Chinese, 80 or 90 cents, without board. I put 4 and 5 large shovelfuls to each hill, and after going over all the hills, if there is a surplus, I shall put some between the hills.

As this is my first year with the sweepings, I can not report any results.

DANIEL FLINT.

FINDLAY, OHIO, *October 23, 1897.*

Street sweepings cost me 15 cents per load. I use them without preliminary treatment for garden crops, and consider them very valuable.

M. M. LOWN, M. D.

SAVANNAH, GA., *November 9, 1897.*

Street sweepings, if put together and allowed to ferment and ripen, form a capital top dressing for truck gardens, etc.

J. C. LE HARDY.

HIGHLAND PARK, PITTSBURG, PA., *November 23, 1897.*

I have been using street sweepings in the park for a period of three years and I find it an excellent fertilizer. It has given good satisfaction so far as we have tried it. The soil in the park is of a clayey nature, and I get the best results from applying about 4 to 6 inches, owing to the quality of the soil, then cultivating, rolling, etc., before sowing the lawn seed. With the above treatment our lawns stand the drought, give a rich, green color, and are very pretty. I have not used the street dirt in connection with any crop other than the making of lawns. As to the cost, the hauling from the freight station is the only expense we have. It costs us about 50 cents per cubic yard.

As to the rubbish, there are some tin cans and other materials mixed through it, but it is a small percentage.

GEO. W. BURKE.

BOX 463, PULLMAN, ILL., *November 29, 1897.*

I had some experience thirty-five years since in using street sweepings for a fertilizer from the city of New York, 35 miles distant, brought to the farm by sailboat, but found the material too bulky for the amount of fertilizing matter contained to pay for transportation and handling for use in growing vegetables and the ordinary farm crops and nursery stock.

R. B. HANCE.

MARSHALSEA, PA., *December 6, 1897.*

We have used street sweepings for four years and find it a fine fertilizer. In fact, we use no other kind. We have one 22-acre field, high ground; this field was only a briar patch; would raise nothing. After giving it a coat of street sweepings it produced a fine crop of oats, 45 bushels per acre, and a very heavy crop of English clover. A part of this field was not fertilized with street sweepings. The part not fertilized produced two-thirds less than that part of the field fertilized. Cost of street sweepings, $6 per car freight, the street department of the city loading car and the insane labor at the farm unloading. We find some tin cans and other rubbish, but this is taken out when unloading car, at a trifling cost.

GEO. LINDERMAN.

LYNCHBURG, VA., *December 13, 1897.*

I have used street sweepings, and I think they are worth to a farmer about two-thirds as much as any stable or cow-pen manure where straw bedding is used. The cost of the same depends on how far they are to be hauled. I never investigated the cost, and used them in top dressing for grapes, which I think gave fine results.

L. F. LUCADO.

NORFOLK, VA., *December 18, 1897.*

I have been using street sweepings for several years with much satisfaction and profit on spinach, cabbage [compare with letter from Mr. Hathaway, of Muncie, Ind., given above.—E. E. E.], kale and potatoes. I haul the material on my farm near where I purpose using it, putting 300 or 400 loads in a heap. I then fork or shovel it over, separating the bricks, tin cans, paper, and other rubbish as thoroughly as I can (a coarse screen would be better). For spinach, I use it broadcast at the rate of 700 bushels per acre; for cabbage, I drill it at the rate of 500 bushels per acre, and ridge the land; for potatoes, I think it better to broadcast, as for spinach and kale. I use from 2,500 to 3,500 carloads of 25 bushels each, and have been using it for the last ten or twelve years. I use, in addition, about 1,000 carloads of stable manure, and as a rule 300 tons of commercial fertilizer. The street sweepings cost me 20 cents a carload at the dump. The effect on the land where street sweepings are used is much more lasting than where stable manure is used. On "gally" places, that will not grow crops, such a dressing as I have named makes them produce good crops.

THOS. R. BALLENTINE.

PITTSBURG, PA., *December 18, 1897.*

We use street sweepings very largely in our parks and with excellent results. We get the sweepings and dump them in a pile, like a manure heap, 3 to 5 feet deep, driving over it with the wagons, then squaring it up, leaving it sagging a little on top to catch water. It is left in this way for at least a year, or maybe two years, turned once if we have time, and then used as a top dressing on lawns, say one-fourth inch thick, or to mix in with soil in breaking up land, when we use it 1 to 2½ inches deep. It is powerful and quick in its action, and gives a capital growth of grass, and its effect is more lasting than that of artificial manures.

To use it fresh is dangerous, that is, if a heavy dressing is given, and a thin dressing is of little use. To be of any practical benefit, it should be well rotted and well wetted, either by rain or artificial watering from the first; if stacked dry, it "burns." When well rotted, it forms a black mass of humus.

We have 195 carloads of street sweepings in one pile now, all unloaded there this summer; while we were getting them we got in two to three carloads a day. They were emptied and the dumpings piled close by the railroad in a big heap, too big for their good, but we had no time then to take care of them; we left that job till frosty weather, when we could haul them to a more convenient place. In unloading them we throw all big sticks, stones, tin cans, leather straps, iron scrap, etc., aside.

WM. FALCONER.

FURTHER COOPERATION WITH THE DIVISION IN THE STUDY OF THE FERTILIZING VALUE OF STREET SWEEPINGS INVITED.

It is hoped that the information contained in the quotations from letters given above will serve as an inducement for the extension of the use of street sweepings for fertilization, and also aid in developing the best methods for collecting, preparing, and applying the material to the soil. Correspondence is invited with persons interested in the subject, or with farmers or gardeners who have made careful experiments in the use of street sweepings or other forms of city wastes for purposes of fertilization. A knowledge of their methods and results will be of value to others, whether their experiments are successful or unsuccessful. Reports of experiments of this kind possess their maximum value only when the purchase price and cost of hauling, preparing, and applying the fertilizer to the land are stated; when a part of the land is left unfertilized and the crops on fertilized and unfertilized portions of the field are harvested and measured separately; and when the net profit per acre in each case is accurately stated.

MONEY VALUE OF STREET SWEEPINGS.

Without a knowledge of the results of a large number of carefully conducted experiments, it would be hard to determine from the results of an analysis just what price per ton farmers can afford to pay for street sweepings in addition to the cost of hauling and spreading them on the land. Using the very conservative estimate of 10 cents per pound for the nitrogen, and disregarding the phosphoric acid and potash, the poorest sample analyzed, Serial No. 17034, would be worth 34 cents per ton; while the richest sample, Serial No. 17219, would be worth $1.46 per ton. The material has considerable value for many soils in addition to the value of the plant food it contains. Gardeners declare that it is very useful for improving the mechanical condition of stiff and badly aerated soils. It would also improve the condition of very light soils which are deficient in moisture-holding capacity because of the low percentage of organic matter which they contain.

The nitrogen of street sweepings is not as readily available as the nitrogen of ordinary stable manure, because of the smaller proportion of urine contained in the sweepings. It is a well established fact that the nitrogen in the urine of animals is much more readily available than that contained in their solid excrement. It is, therefore, very difficult to make an estimate of the money value of street sweepings because of the great variation in their composition, which is dependent upon the nature of the pavements, the season of the year during which they are collected, the manner of collection, etc., and because many accurate field tests must be made before we can determine their exact value as a source of plant food. Sixteen cities reported the prices at which street sweepings are sold to farmers by their street-cleaning departments or contractors. These prices vary from 15 cents to $2 per ton. The city of Atlanta reports a contract for the sale of the sweepings of their streets for $60 per year and an arrangement which gives the street-cleaning department the advantage of a short haul. This seems to be an excellent arrangement for both parties concerned, as the average quality of the entire product of a city for a whole year ought not to vary greatly from year to year. Moreover, the price can be adjusted equitably from year to year as the true value of the material becomes apparent.

The expense of hauling can be reduced in a measure by spreading the sweepings in thin layers on the dumping grounds and allowing them to dry out for a day or two before hauling them to the farm. The nitrogen of the material is not of such a form that serious loss would result from this treatment unless it be continued for several days. Long exposure in thin layers during a rainy season would be certain to cause a considerable loss of the most valuable plant food, because that which is most easily leached out is the most readily available.

MISCELLANEOUS WASTE PRODUCTS.

It may often happen that the "dumps" whence the farmer must take his supply of street sweepings, also contain other materials possessing considerable fertilizing value. Any waste animal or vegetable matter, not contaminated with the germs of diseases of men or animals, may very properly be tested in regard to their value for this purpose. Several hundred pounds of fish refuse, of which the composition is shown in the table of analyses on page 11, were found on one of the "dumps" in Washington, D. C. Its source could not be ascertained. Its fertilizing value, based on data used by the experiment stations for the valuation of fertilizers, would vary from $9 to $32 per ton, according to the degree of fineness of the ground material.

BULLETIN NO. 56.

U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF CHEMISTRY.

PROCEEDINGS
OF THE
FIFTEENTH ANNUAL CONVENTION
OF THE
ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS
HELD AT
WASHINGTON, D. C.,
NOVEMBER 11, 12, AND 14, 1898.

EDITED BY
HARVEY W. WILEY,
SECRETARY OF THE ASSOCIATION.

WASHINGTON:
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1899.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Division of Chemistry,
Washington, D. C., January 17, 1899.

Sir: I have the honor to transmit to you herewith the manuscript of the proceedings of the fifteenth annual convention of the Association of Official Agricultural Chemists, with the request that it be published as Bulletin No. 56 of the Division of Chemistry.

H. W. Wiley,
Chief of the Division of Chemistry and Secretary of the Association of Official Agricultural Chemists.

Hon. James Wilson,
Secretary of Agriculture.

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PROCEEDINGS OF THE FIFTEENTH ANNUAL CONVENTION OF THE ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS.

FIRST DAY.

FRIDAY—MORNING SESSION.

The fifteenth annual convention of the Association of Official Agricultural Chemists, beginning November 11, 1898, was called to order in the lecture hall of the Columbian University, by the president, Mr. A. L. Winton, at 10.15 a. m.

MEMBERS AND VISITORS PRESENT.

The following members and visitors were in attendance:

Allen, E. W., Office of Experiment Stations, Department of Agriculture, Washington, D. C.
Alvord, H. E., Dairy Division, Department of Agriculture, Washington, D. C.
Anderson, Cyrus N., Washington, D. C.
Andrews, W. H., Agricultural Experiment Station, Geneva, N. Y.
Atwater, W. O., Storrs Experiment Station, Middletown, Conn.
Bartlett, J. M., Agricultural Experiment Station, Orono, Me.
Beal, W. H., Office of Experiment Stations, Department of Agriculture, Washington, D. C.
Bigelow, W. D., Division of Chemistry, Department of Agriculture, Washington, D. C.
Blair, A. W., Agricultural Experiment Station, Raleigh, N. C.
Bolton, H. Carrington, Washington, D. C.
Cameron, F. K., Division of Soils, Department of Agriculture, Washington, D. C.
Cameron, George W., College Park, Md.
Carpenter, F. B., Virginia-Carolina Chemical Company, Richmond, Va.
Carr, Oma, Corry, Pa.
Coates, Charles E., Louisiana State University, Baton Rouge, La.
Craighill, George P., Lynchburg, Va.
Ewell, E. E., Division of Chemistry, Department of Agriculture, Washington, D. C.
Frear, Wm., Agricultural Experiment Station, State College, Pa.
Gaines, Richard H., Department of Agriculture, Richmond, Va.
Gascoyne, W. J., Baltimore, Md.
Goessmann, C. A., Hatch Experiment Station, Amherst, Mass.
Goessmann, C. I., Hatch Experiment Station, Amherst, Mass.
Grindley, H. S., Urbana, Ill.
Hartwell, B. L., Agricultural Experiment Station, Kingston, R. I.
Haywood, J. K., Division of Chemistry, Department of Agriculture, Washington, D. C.

Hills, J. K., Agricultural Experiment Station, Burlington, Vt.
Hiltner, R. S., Agricultural Experiment Station, Lincoln, Nebr.
Hite, B. H., Agricultural Experiment Station, Morgantown, W. Va.
Holland, E. B., Hatch Experiment Station, Amherst, Mass.
Huston, H. A., Agricultural Experiment Station, Lafayette, Ind.
Jaffa, M. E., Agricultural Experiment Station, Berkeley, Cal.
Jones, C. H., Agricultural Experiment Station, Burlington, Vt.
Kedzie, R. C., Agricultural College, Agricultural College, Mich.
Kerr, G. A., Columbus, Ind.
Kilgore, B. W., Agricultural and Mechanical College, College, Miss.
Krug, William H., Division of Chemistry, Department of Agriculture, Washington, D. C.
Langworthy, C. F., Office of Experiment Stations, Department of Agriculture, Washington, D. C.
Laughlin, J. R., Agricultural College, College Park, Md.
McCarty, R. Lee, New York.
McDonnell, H. B., Agricultural College, College Park, Md.
Meng, James S., New York.
Mitchell, W. L., Agricultural Experiment Station, New Haven, Conn.
Moore, C. C., Division of Chemistry, Department of Agriculture, Washington, D. C.
Morse, F. W., College of Agriculture and Mechanical Arts, Durham, N. H.
Myers, John A., New York.
Palmer, T. Chalkley, Philadelphia, Pa.
Patterson, H. J., Agricultural Experiment Station, College Park, Md.
Peebles, A. B., Storrs Experiment Station, Storrs, Conn.
Ross, B. B., Agricultural Experiment Station, Auburn, Ala.
Runyan, E. G., Division of Chemistry, Department of Agriculture, Washington, D. C.
Schulte, J. I., Washington, D. C.
Schweinitz, de, E. A., Bureau of Animal Industry, Department of Agriculture, Washington, D. C.
Scovell, M. A., Agricultural Experiment Station, Lexington, Ky.
Seal, Alfred N., Washington, D. C.
Skinner, W. W., Agricultural College, College Park, Md.
Snyder, Harry, Agricultural Experiment Station, St. Anthony Park, Minn.
Stewart, J. H., Agricultural Experiment Station, Morgantown, W. Va.
Stokes, H. N., Geological Survey, Washington, D. C.
Street, John Phillips, Agricultural Experiment Station, New Brunswick, N. J.
Trescot, T. C., Division of Chemistry, Department of Agriculture, Washington, D. C.
True, A. C., Office of Experiment Stations, Department of Agriculture, Washington, D.C.
Van Slyke, L. L., Agricultural Experiment Station, Geneva, N. Y.
Veitch, F. P., Agricultural College, College Park, Md.
Voorhees, L. A., Agricultural Experiment Station, New Brunswick, N. J.
Wheeler, H. J., Agricultural Experiment Station, Kingston, R. I.
Wiley, H. W., Division of Chemistry, Department of Agriculture, Washington, D. C.
Williams, C. B., Agricultural Experiment Station, Raleigh, N. C.
Winton, A. L., Agricultural Experiment Station, New Haven, Conn.
Withers, W. A., Agricultural Experiment Station, Raleigh, N. C.
Woll, F. W., Agricultural Experiment Station, Madison, Wis.
Woods, Charles D., Agricultural Experiment Station, Orono, Me.
Yocum, J. H., New York.

ORDER OF BUSINESS.

In compliance with the action taken at the last meeting of the association, the executive committee reported the following order of business:

The president's address.

Reports of the referees in the following order:

First. Report on nitrogen.

Second. Report on potash.

Third. Report on phosphoric acid.

Fourth. Report on soils and ash.

Fifth. Report on foods and feed stuffs.

Sixth. Report on food adulteration.

Seventh. Report on dairy products.

Eighth. Report on sugars.

Ninth. Report on tannin.

Tenth. Report on nicotin.

Eleventh. Reports of special committees (abstract committee, food standards, uniform laws for fertilizer control, volumetric standards, rewriting methods of soil analysis).

The president appointed Messrs. McDonnell, Bigelow, and Wheeler a committee on time of meeting. The committee recommended that two sessions be held daily, one from 9.30 a. m. to 12 noon and the second from 1.15 to 4 p. m. The recommendation of the committee was adopted.

The president made the special order for the election of officers for 2 p. m. on Saturday.

The president of the association then read the following annual address:

ADDRESS OF THE PRESIDENT.

MEMBERS OF THE ASSOCIATION OF OFFICIAL CHEMISTS: Our association came into existence at a time when there was especial need of such an organization. The official agricultural laboratories in the United States were few in number, limited in experience and resources, and continually harassed by controversies with fertilizer manufacturers over the accuracy of their analytical work. The cooperative study of methods, which was undertaken soon after organization was effected, brought the individual chemists into closer touch, and the methods adopted not only came into use in all the official laboratories, but were soon recognized as standard methods by the trade.

The passage of the Hatch act gave to each State abundant means for agricultural investigation, a considerable part of which was devoted to chemical work. But as the laboratories increased in numbers and efficiency the demands on the association, instead of becoming less, became greater, and much discretion was required in determining the policy to be pursued. To-day, although we have been organized for over fourteen years, we are still confronted by a number of questions of policy which demand our careful attention.

The first of these concerns the scope of the association. The name under which we are known gives little idea of our purpose and work. Agricultural chemistry, in the full significance of the term, is not merely a branch of chemistry, but is a comprehensive science which includes animal and plant physiology, physics, and other sciences so far as they are applied to agriculture. The well-known Jahresbericht über die Fortschritte auf dem Gesamtgebiete der Agrikultur-Chemie for 1896 reviews the work of the year under the following heads: atmosphere, water, soils, fertilizers, physiology of plants, constituents of plants, seed testing, plant culture, plant diseases, fodders, constituents of animal bodies, chemico-physiological experiments on animals (including bees, silkworms, and fishes), animal nutrition, meat and milk production, dairy products, starch production, sugar production, diseases of the sugar beet, wine, liquors, and, finally, methods of analysis. Of the 700 pages but 55 are devoted to the latter subject.

Notwithstanding this long list of subjects which come within the scope of agricultural chemistry, we, as an association, have confined our attention almost entirely to matters pertaining to agricultural analysis. Our everyday work, it is true, is carried on in the field and in the stable as well as in the laboratory; but once a year we leave the crops and the farm animals behind and meet as analytical chemists.

During the first two years of its existence our organization was really a body of fertilizer analysts, as only methods for the analysis of these materials were considered; but at the third convention the constitution was amended so as to include as subjects for investigation "The analysis of soils, cattle foods, dairy products, and other materials connected with agricultural industry." The subjects fodders and dairy products were referred that year (1886) to committees, and sugar and distilled liquors in the following year. The first reporter on soils and ash was appointed in 1890 and on tannin in 1894. The methods for the analysis of dairy products and liquors which were tested included those for the detection of adulteration, and in 1896 this line of investigation was extended so as to cover all articles used for food and drink, a task which bids fair to become one of the most important we have yet undertaken.

Although from time to time the field of our labor has been enlarged, it really has never been extended beyond the bounds of chemical analysis, and it is believed that we have attained a much higher degree of usefulness under these limitations than would have been possible in a broader field.

But, while it is advisable that we remain an association of agricultural analysts, we should be this in the fullest sense. At the present convention Dr. de Schweinitz is expected to present a paper on the determination of nicotin in tobacco powders and tobacco extracts.

These products are coming into extensive use as insecticides and, as their value is dependent chiefly on the percentage of nicotin they contain, it is important that suitable methods be employed in determining this ingredient.

In addition to tobacco preparations, various other insecticides (chiefly arsenical powders), as well as fungicides, are frequently analyzed in official laboratories, and it seems to me desirable that a referee on insecticides and fungicides be appointed each year, to investigate methods for the determination of the valuable constituents of these products.

There is no immediate prospect that a further expansion of our work will be found advisable. The agricultural chemist may be called upon occasionally to analyze other classes of materials, such as, for example, well waters, paints for farm buildings, lubricants for farm machinery, and even wall paper for farm houses and grange halls, but these do not demand our attention as an association.

The second problem which confronts us is whether referees are to conduct cooperative investigations solely to study analytical methods, or, in part, to determine the accuracy of the work of the individual analysts. At the outstart samples were distributed, chiefly with the view of comparing the results obtained in different laboratories by the same methods. Such comparisons, while very instructive indeed to those making the analyses, did not, however, bring out any facts of general interest and it soon became apparent that results of more permanent value could be secured in the study of analytical methods. This latter work was accordingly taken up and has since resulted in many improvements of analytical processes, both as to accuracy and convenience. Unfortunately, the referees have been seriously hampered in their investigations, owing to the practice in some laboratories of using the samples sent out by the referees for a test of analysts rather than of methods. As a consequence of this abuse, it has been difficult to decide whether the method or the analyst was at fault. The referees are selected because of special qualifications for their work and they, in turn, should choose associates who are not only skilled manipulators, but have given particular attention to the subject under investigation. Furthermore, every official chemist should have it impressed upon him that it is better to decline to take part in an investigation than to assign the details to an inexperienced assistant.

Our plan of testing methods by the analysis of a few samples sent out by the referees, while in some respects an excellent one, is still open to grave criticism. If a considerable number of chemists secure good results by a new method in the analysis of three or four samples, the accuracy of the method is too often regarded as established. The fact is overlooked that it is the samples which have been thoroughly tested, whereas the method has been given only a preliminary trial. A method which works well on four samples but fails in the fifth is a snare and a delusion. It is, therefore, of vastly greater importance that a wide variety of materials be examined by a few expert analysts than that a few materials be examined by a large number of analysts, and the best way to secure this variety is for each analyst to select his own materials. The analyst must, of course, make comparative determinations on each sample by the method under trial and a standard method, and for the purpose of eliminating from the comparison any possible errors due to variation in the sample, imperfect solution, or other cause, he should, whenever possible, use aliquots from the same solution. Many times these comparisons can be made on samples analyzed in connection with station work, and the results will have an immediate value, aside from throwing light on the methods.

The action taken at the last convention, leading to the appointment of a committee to consider standards of purity of the foods and drinks on sale in the United States, was but another manifestation of the growing determination to suppress adulteration and misbranding. The adoption of standards of purity should go hand in hand with the adoption of methods of examination, as the proper interpretation of results is as essential as the accuracy of their determination.

The undertaking is, however, fraught with difficulties and dangers and involves much patient and thoughtful work. Above all things we should avoid undue haste, as mistakes at the beginning will work incalculable harm.

In the case of some classes of foods, the data at hand are insufficient to serve as a suitable basis for standards and there is need of more analyses of authentic samples. This is particularly true of the spices, which subject was assigned to me by the committee. A considerable number of authentic samples, that is to say, samples ground in the laboratory from whole spices, were examined at the Department of Agriculture over eleven years ago, as described in Bulletin 13, part second, Spices and Condiments, but these results should be supplemented by analyses of the grades now on our markets. Some three months ago, I wrote to leading spice importers in New York City and Boston, asking if such samples could be secured. Three of the largest houses in New York and one in Boston at once replied that I was at liberty to sample all the goods in their warehouses from the original, unbroken packages. Through their courtesy over one hundred samples, representing all grades and qualities, have been drawn and the laborious task of analyzing these samples is now under way.

It thus appears that the work of fixing standards is not merely clerical, but involves the making of a large number of chemical analyses.

Another difficulty in fixing standards is the wide variation in quality, and, consequently, in composition, of foods. In our investigation of the spices this has already become apparent. For example, Singapore black pepper is a hard and perfect berry and, consequently, contains a higher percentage of starch and a lower percentage of fiber than the lower grades of Acheen pepper, in which there are many empty shells. Ginger and cassia also vary greatly in quality and composition.

If we adopt standards based on analyses of the better grades, we shall be liable to condemn as adulterated inferior, but genuine, products, and thus work great injustice. It is, therefore, of the utmost importance that all grades be examined before attempting to fix standards.

Again, it is often difficult to decide as to what constitutes adulteration. A few examples drawn again from the spices will make this point clear. Black pepper, as you all know, is the unripe berry of the pepper plant, dried without shelling; white pepper is the mature berry from which the outer coatings have been removed. The pepper shells obtained as a by-product in preparing white pepper are extensively mixed with ground black pepper. This practice is regarded by food analysts as an adulteration analogous to the addition of skim milk to whole milk. The spice grinders, as a rule, take the ground that, since the pepper shells are a product from pepper which have about the same strength and chemical composition as the low grades of black pepper, their use is legitimate. They say that, even if it is granted, for the sake of argument, that pepper shells are an adulterant, it is impossible to distinguish between ground black pepper thus adulterated and that obtained by grinding a low-grade Acheen pepper, which contains shells as an accidental impurity.

The addition of ground clove stems to ground cloves is commonly prohibited, as the former contain but about 4 per cent of volatile oil, whereas the cloves contain upward of 20 per cent. The grinders claim that, since clove stems are always present in small amount in cloves as an accidental impurity, they should be rated as a low grade of cloves.

Assuming that both pepper shells and clove stems are adulterants, where shall the line be drawn between accident and design?

A similar problem was encountered years ago in fixing milk standards. It was evident that standards based on the minimum percentage of solids and fat which genuine milk ever contained would be so low as to be of little value in preventing adulteration. The only solution of the problem was to adopt arbitrary standards, so that milk which was abnormally low in nutritive value could not be sold under the name "milk," whether or not it had been skimmed or watered.

Another important question concerns the coloring of foods. Some are of the opinion that for the proper enforcement of pure-food laws it is necessary to regard all artificial coloring matters as adulterants, except when their presence is distinctly stated on the package, while others contend that only dyes injurious to health, or those added to conceal damage or the presence of makeweights, should be placed in this category. Whatever decisions are reached in this matter, common justice demands that the same rule shall be applied to one class of foods as to another. If the dairyman is allowed to color his butter and the farmer his vinegar, the spice grinder should certainly have the privilege of adding to mustard enough turmeric to give it the attractive color which the housewife demands—a practice which a gentleman high in the trade has pronounced in my hearing as no more culpable than decorating the dining table with flowers or garnishing beefsteak with parsley.

These illustrations have been drawn from the spices for the reason that I am at present specially interested in these products; but similar difficulties are to be encountered in fixing standards for other classes of foods, and great care should be taken in reaching final decisions.

I have purposely omitted all mention of the specific problems in analytical chemistry for which we are seeking solutions, as these will be fully presented by the referees during our sessions. There is no limit to the work in this our chosen field. The methods for the proximate analyses of fodders and soils especially need improvement, and even the subjects nitrogen, phosphoric acid and potash, over which we have labored since our first convention, are not yet exhausted.

It is well that there are many workers and that there is a division of the labor.

APPOINTMENT OF COMMITTEES.

The president appointed the following committee on recommendations of referees: Messrs. Huston, Ross, and Street, together with the referee whose recommendations were to be considered.

The president appointed Messrs. Kedzie and Jaffa as a committee to wait upon the Secretary and Assistant Secretary of Agriculture and invite them to attend the meeting.

The preliminary business having been accomplished, the president announced that the order of business which had, by the vote of the previous convention, been left with the executive committee would now be followed, and called first for the reading of the report of the referee on nitrogen. The referee, Mr. R. J. Davidson, being absent on account of illness, his report was read by the secretary.

REPORT ON NITROGEN.

By R. J. DAVIDSON, *Referee.*

In outlining the work for the year the referee tried to follow as closely as possible the instructions and suggestions made at the last meeting of the association.

It was recommended that a further investigation of the Ulsch-Kjeldahl and Ulsch-Gunning methods for total nitrogen be made, and in addition to continue the work on methods for the determination of available nitrogen in mixed fertilizers, with special reference to rapidity and reliability.

About the middle of February a letter was sent to a number of chemists asking them to take part in the work, and favorable responses were received from eleven. Some of these stated that they would do only part of the work. Eleven sets of materials were sent out about March 8, and about a month later another set was called for.

From these twelve sets of samples I have received up to the present time reports from two chemists on all the work, and from eight, reports on part of it.

For work in comparing the Ulsch-Kjeldahl and Ulsch-Gunning methods with the official methods, the following letter of instructions was sent:

MARCH 8, 1898.

DEAR SIR: With the organic sample I also send you two samples to be used in testing the Ulsch-Kjeldahl and Ulsch-Gunning methods for total nitrogen in sample rich in nitrate salts.

Sample No. 11 consists of a mixture of sodium nitrate, cottonseed meal, acid phosphate, and sodium chlorid.

Sample No. 12 consists of a mixture of sodium nitrate, cottonseed meal, tankage, and acid phosphate.

You are requested to make the following determinations in each sample:

A.—Total nitrogen by Kjeldahl and Gunning methods modified to include nitrates.

B.—Total nitrogen by Ulsch-Kjeldahl method.

C.—Total nitrogen by { Ulsch-Gunning method.
{ Ulsch-Kjeldahl method.

Place 1 gram of sample in a Kjeldahl flask, add 20 cc of water, shake, and allow to stand for ten minutes. Then add 3.5 grams of powdered iron (reduced iron answers very well) and 10 cc of sulphuric acid (sp. gr. 1.35), warm gently until evolution of hydrogen ceases; add 0.7 gram of mercuric oxid and 20 cc of strong sulphuric acid, and then proceed as in the regular Kjeldahl method.

ULSCH-GUNNING METHOD.

Proceed as in Ulsch-Kjeldahl method until conversion has been made with reduced iron and sulphuric acid, and then follow the regular Gunning method, using from 25 to 30 cc sulphuric acid for digestion instead of 20 cc.

It is requested that all results be reported as soon as possible.

Respectfully, yours,

R. J. DAVIDSON, *Referee.*
F. S. SHIVER, *Associate.*

The methods given above are the same as those used last year, except as to the quantity of reduced iron, which has been changed from 2 to 3.5 grams.

The materials used in the preparation of the above samples were as follows:

Sample No. 11:

20 grams nitrate of soda, containing 3.22 grams nitrogen.
100 grams cottonseed meal, containing 7.60 grams nitrogen.
100 grams acid phosphate.
70 grams sodium chlorid.

This sample contains 8.48 per cent of total nitrogen, of which 6.85 per cent are nitric nitrogen.

Sample No. 12:

150 grams nitrate of soda, containing 24.165 grams nitrogen.
100 grams cottonseed meal, containing 7.60 grams nitrogen.
100 grams tankage, containing 5.89 grams nitrogen.
170 grams acid phosphate.

This sample contains 7.24 per cent of total nitrogen, of which 4.65 per cent are nitric nitrogen.

In preparing these mixtures it was intended to have considerable nitric nitrogen present to test the serious objections raised at the last meeting against the Ulsch-Kjeldahl and Ulsch-Gunning methods.

It was stated then that the quantity of iron used (2 grams) was not sufficient when the per cent of nitric nitrogen present was 4 or over.

Before sending out these samples both the referee and the associate referee made several determinations, using 2, 2.5, 3, 3.5, and 4 grams of iron with 1 gram substance, to find out what was the smallest quantity of iron necessary, and it was found that not less than 3.5 grams should be used for No. 11, and that perhaps 4 grams would be better. But, as the main object of this investigation was to obtain information as to the amount of iron that should be used, it was thought best to limit the amount to 3.5 grams.

Comparison of methods.—Total nitrogen.

Analyst.	11					12				
	Modified Kjeldahl.	Modified Gunning.	Absolute.	Ulsch-Kjeldahl.	Ulsch-Gunning.	Modified Kjeldahl.	Modified Gunning.	Absolute.	Ulsch-Kjeldahl.	Ulsch-Gunning.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
A. W. Ogden, Conn. Station	8.36	8.34	......	8.42	8.34	7.21	7.21	......	7.24	7.17
	8.38	8.36	......	8.48	8.37	7.23	7.23	......	7.27	7.18
	8.42	8.36	......	......	8.38	7.27	7.27	......	7.28	7.20
	8.48	8.41	......	......	......	7.28	7.30	......	7.30	7.22
F. Thompson, N.Y. Station	......	8.38	......	......	[1]8.37	......	7.20	......	......	7.20
	......	8.44	......	......	[1]8.41	......	7.20	......	......	7.16
	......	......	......	......	......	......	7.31	......	......	7.18
T. C. Trescot, U. S. Dept. Agr	......	[2]8.74	[2]8.72	......	[2]8.70	......	[2]7.46	[2]7.47	......	[2]7.48
	......	[2]8.76	[2]8.69	......	[2]8.70	......	[2]7.51	[2]7.41	......	[2]7.45
	......	[2]8.70	......	......	[2]8.76	......	[2]7.51	......	......	......
	......	......	......	......	......	......	[2]7.47	......	......	......
Walker Bowman, Louisville Spirit-Cured Tobacco Co	8.57	......	......	......	......	7.26	......	......	......	......
C. H. Jones, Vt. Station	8.47	......	......	8.40	8.41	7.24	......	......	7.21	7.21
	8.48	......	......	8.39	8.40	7.25	......	......	7.19	7.27
	8.56	......	......	8.42	8.44	7.25	......	......	7.16	7.24
	8.54	......	......	......	......	7.19	......	......	......	......
	8.57	......	......	......	......	......	......	......	......	......
H. K. Miller, N. C. Station	8.39	......	......	8.40	......	7.32	......	......	7.20	......
	8.36	......	......	8.30	......	7.35	......	......	7.11	......
	8.41	......	......	8.30	......	......	......	......	7.26	......
	[2]8.27	......	......	......	......	......	......	......	......	......
W. B. Ellett, Va. Station	8.56	......	......	8.34	......	7.22	......	......	7.21	7.21
	8.48	......	......	8.38	8.39	7.35	......	......	7.20	7.26
A. T. Eskridge, Va. Station	......	......	......	8.49	......	......	......	......	7.34	......
	8.47	......	......	8.38	8.30	......	......	......	7.21	......
J. P. Street, N. J. Station	8.34	......	......	8.25	8.25	7.20	......	......	7.13	7.16
	8.34	......	......	8.31	8.25	7.21	......	......	7.19	7.13
	8.34	......	......	8.28	8.25	7.21	......	......	7.16	7.15
F. S. Shiver, S. C. Station	8.56	......	......	8.57	8.63	7.29	......	......	7.28	7.23
F. P. Veitch, Md. Station	......	8.32	......	......	......	......	7.14	......	......	......
	......	8.36	......	......	......	......	7.16	......	......	......
Average	8.45	8.37	......	8.38	8.37	7.26	7.22	......	7.22	7.20
Theory	8.47	......	......	......	......	7.24	......	......	......	......

[1] Not included in averages, as Mr. Thompson used more iron than was called for in the instructions.
[2] Not included in averages.

NOTES BY THE ANALYSTS.

A. W. Ogden.—The samples seemed a little coarse for nitrogen determination, so I ground same to pass a 0.04 inch sieve. This extra exposure during grinding may have changed the water content a trifle, still I think not notably.

F. Thompson.—The Ulsch-Gunning method was attended with serious frothing and bumping, which could not be readily overcome except by distilling by a current of steam.

J. P. Street.—The Ulsch-Gunning method, while it gives results concordant with the other methods, is very difficult of manipulation. Sample No. 11 gave more tron e than the other, probably because of the chlorids present. The large amount of material in the flask makes prevention of bumping almost impossible, and in my mind militates strongly against the method.

F. P. Veitch.—Ulsch-Gunning method. This spring I attempted to do some work with this method, comparing it with the regular Gunning for nitrates. I started about 50 samples, but the heavy precipitate caused such violent bumping that more than half of the flasks was broken, and in nearly all other cases soda was carried over.

T. C. Trescot.—

Detailed results of determination of nitrogen in Association of Official Agricultural Chemists' official samples for 1898 by the Ulsch-Gunning method.

Successive distillations.	Serial No. 17239. Referee's No. 11.			Serial No. 17240. Referee's No. 12.	
	Per cent nitrogen.	Per cent nitrogen.	Per cent nitrogen.	Per cent nitrogen.	Per cent nitrogen.
1	8.47	8.37	8.48	7.34	7.23
2	.11	.11	.08	.08	.11
3	.06	.08	.08	.06	.11
4	.06	.08	.00	.00	.00
5	.00	.06	.06	....	....
6	....	.00	.00	....	....
Total	8.70	8.70	8.76	7.48	7.45
Average	8.72			7.46	

In the five series of determinations of nitrogen by the Ulsch-Gunning method which are reported above, after the distillation had been completed the residue in the distilling flask was diluted with water and a fresh portion of zinc was added (the quantity usually used for each distillation). The distillation was then repeated, and the quantities of nitrogen indicated under "Distillation No. 2" in the table were obtained. The dilution, addition of zinc, and redistillation were repeated until no more nitrogen came over. In two cases six distillations were necessary before this was accomplished.

It would seem from these results that the reduction of the nitric nitrogen had been incomplete during the treatment with iron, and was completed only by the long treatment with zinc in alkaline solution during the distillation.

The results reported by the modified Kjeldahl in both Nos. 11 and 12 are fairly good, the greatest variation from theory being 0.2 per cent, which occurs in No. 11. Eliminating this result, the greatest difference between the lowest and theory is 0.13 per cent. This is more than it should be, considering that this is one of our standard methods. The results in No. 12 are much better, the widest variation from theory being 0.05 per cent.

With the exception of one set of results, which is about 0.25 per cent higher than theory, what is said about the Kjeldahl method will apply to the Gunning, except that it is slightly lower in the general average. In case of No. 12, eliminating one set of results, which varies from theory about the same as a similar set in No. 11, that is, by 0.25 per cent, the other results by the Gunning are very good.

The results by the Ulsch-Kjeldahl and Ulsch-Gunning methods, with the exception of one set, are very satisfactory. This set exhibits the same difference here that it did in case of the regular official methods. Eliminating this set and comparing the Ulsch-Kjeldahl and Ulsch-Gunning in No. 11, it seems that the results are not quite so good as those obtained by our official methods. With the exception of three results which are about the same as theory, all the others are slightly lower, the lowest being 0.22 per cent below theory; and the general average of all the results is 0.09 per cent below theory in the Ulsch-Kjeldahl and 0.10 in the Ulsch-Gunning method.

The low results given in sample No. 11 by these methods show very clearly that in a sample like this, containing 6.85 per cent of nitric nitrogen, 3.5 grams of iron are not sufficient, and that 4 grams should have been used in order to obtain satisfactory and concordant results. The results obtained by these methods in No. 12 are excellent. The greatest variation between the lowest result and theory is 0.11 per cent, just one-half what it was in the case of No. 11, and the general average is only 0.04 from theory. Of the thirty-two results in sample No. 12 by these methods, only 9 vary more than 0.06 per cent from theory.

It appears from the results with No. 12 that 3.5 grams of iron were certainly sufficient to reduce all the nitrate, and, judging from the results obtained in the case of No. 11, that less than the 3.5 grams would have done; but unfortunately we have no data to prove this.

From the results obtained in our work in these two samples, we ought to be able to lay down the following rule as to the quantity of iron to be used: For every .015 gram of nitric nitrogen present not less than 1 gram of iron should be used. But this point ought, perhaps, to be further investigated.

All the objections to the use of these methods were on account of the bumping caused by the heavy precipitate of iron in the flask. This trouble might be remedied by limiting the quantity of iron to be used in all cases to 2 grams and then regulating the quantity of material to be used by this. Thus, if a fertilizer contain 4 per cent or less of nitric nitrogen, use, say, 0.7 gram, and if more than 4 and less than 7 use 0.5 gram, etc.

On account of sickness the referee was unable to investigate these methods as thoroughly as he had intended; therefore he does not feel justified in making any recommendation as to their adoption.

It would, perhaps, be better to give them another trial.

The work of the determination of the availability of organic nitrogen is a continuation of that of last year, and consists of a further study of the permanganate of potash method in comparison with the pepsin-hydrochloric acid method and a modification of the pepsin method suggested by Mr. Patterson, of Maryland.

In order to carry out this work, ten samples of organic nitrogenous materials were prepared, which were as follows:

No. 1. Dried blood; a low-grade sample.

No. 2. Cottonseed meal.

No. 3. Tankage.

No. 4. Dried fish.

No. 5. Meat scraps.

No. 6. Castor pomace.

No. 7. Steamed leather. This is a sample of the leather used by Dr. Wheeler, of the Rhode Island Station, in his vegetation test.

No. 8. Raw bone.

No. 9. Hoof meal.

No. 10. Dried blood; an average sample. This was also obtained from Dr. Wheeler, and was one of the materials used in his investigation.

As the value of results obtained by chemical methods is dependent upon the relation that these results bear to those obtained by vegetation tests, the referee was anxious to get some of the materials that had been used by the referee of the last year in some vegetation experiments, the results of which were to be ready for publication by this meeting, but, unfortunately, he did not have enough in hand to supply samples.

The materials for samples No. 7 and No. 10 were furnished by Dr. Wheeler. These represent the materials used by him in his vegetation tests upon an acid soil, limed and unlimed. The other samples fairly represent the usual sources of organic nitrogen, and four of these are similar to those used last year.

When the samples and instructions were sent out, the referee requested that the following series of determinations should be made:

(A) *Total nitrogen by Kjeldahl method.*
(B) *Digestion of organic nitrogen by the pepsin-hydrochloric acid method.*
(C) *Digestion of organic nitrogen by the permanganate of potash method.*
(D) *Digestion of organic nitrogen by the modified pepsin-hydrochloric acid method.*

(A) TOTAL NITROGEN BY KJELDAHL METHOD.

TABLE I.—*Results on total nitrogen by the different analysts.*

Analyst.	Dried blood.	Cottonseed meal.	Tankage.	Dried fish.	Meat scraps.	Castor pomace.	Steamed leather.	Bone meal.	Hoof meal.	Dried blood.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
A. J. Patten, Me. Station	9.91	7.63	6.05	8.27	4.61	5.51	7.07	3.88	15.05	12.97
O. W. Knight, Me. Station	9.93	7.67	6.03	8.38	4.66	5.48	6.96	3.84	14.83	12.95
F. Thompson, N. Y. Station	9.94	7.74	5.92	8.26	[1]4.84	5.45	7.02	3.79	14.72	12.91
	9.84	7.70	5.93	8.29	4.71	5.48	6.99	3.76	14.72	12.81
	9.82	7.66				5.52	6.99	3.82	14.84	12.86
C. H. Jones, Vt. Station	9.90	7.74	5.71	8.36	4.50	5.33	7.00	3.82	14.93	13.08
	9.82	7.64	5.73	8.43	4.48	5.24	7.02	3.75	14.91	12.80
T. C. Trescot, U. S. Dept. of Agr	9.98	7.44	5.76	[1]8.06	4.60	5.39	6.91	3.82	14.69	12.78
B. L. Hartwell, R. I. Station	9.71	7.53	5.89	8.23	4.62	5.56	6.93	3.88	......	12.94
Walker Bowman, Louisville Spirit-Cured Tobacco Co	9.97	7.60	5.98	8.52	[1]4.26	5.33	7.14	3.92	15.08	12.80
H. K. Miller, N. C. Station	9.91	[1]7.89	6.05	8.48	4.69	[1]5.67	7.07	3.92	15.01	13.05
	10.02	[1]7.83	6.07	8.51	4.69	5.53	7.08	3.84	14.94	13.05
F. S. Shiver, S. C. Station	10.00	7.68	6.03	[1]8.69	4.76	5.47	7.00	3.89	14.99	12.99
J. P. Street, N. J. Station	9.71	7.51	5.81	8.38	[1]4.37	[1]5.79	6.87	3.85	14.72 14.67	[1]12.66
	9.81	7.44	5.78	8.30	[1]4.34	[1]5.74	6.87	3.83	14.67 14.69	[1]12.66
	9.76	7.48	5.80	8.34	[1]4.36	[1]5.77	6.87	3.85		[1]12.67
W. B. Ellett, Va. Station	9.87	7.58	5.80	8.31	4.50	5.31	6.88	3.79	14.67	12.86
	9.82	7.52	5.79	8.26	4.59		6.80	3.81	14.70	12.97
A. T. Eskridge, Va. Station	9.97	7.68	5.80	8.27	4.56	5.31	6.90	3.80	14.70	13.02
Average	9.87	7.60	5.89	8.35	4.62	5.42	6.96	3.83	14.82	12.92

[1] Omitted from the average.

There was only one comment on this part of the work, and that was by Mr. J. P. Street, who says: "I had considerable difficulty in securing good results in the meat scrap, castor pomace, and hoof meal, in a large measure due, I think, to their mechanical condition."

These remarks probably explain the reason for such wide variations in these samples, as they were not as fine as they should have been, but I do not think this reason can be brought against most of the others, and yet the variation is greater in some of them.

In the two samples of blood, the variation was 0.31 per cent in No. 1 and 0.42 per cent in No. 10; in cottonseed meal, 0.45 per cent; in tankage, 0.36 per cent, and in fish, 0.63 per cent.

The meat scraps show a variation of 0.58 per cent; castor pomace, 0.43 per cent, and hoof meal, 0.38 per cent.

(B) DIGESTION OF ORGANIC NITROGEN BY THE PEPSIN-HYDROCHLORIC ACID METHOD.

The method used in this work was practically the same as that used by the referee on nitrogen for 1896 and 1897, and is given in the proceedings of the association for 1896, page 23.

TABLE II.—*Results on digestion of organic nitrogen, by different analysts.*

Analysts.	Dried blood.	Cottonseed meal.	Tankage.	Dried fish.	Meat scraps.	Castor pomace.	Steamed leather.	Bone meal.	Hoof meal.	Dried blood.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
C. H. Jones and B. O. White, Vt. Station	1.19	0.70	1.36	2.81	1.78	1.19	3.32	0.07	9.52	1.02
	1.13	.70	1.33	2.90	1.82	1.22	3.29	.07	9.66	.98
T. C. Trescot, U. S. Dept. of Agr	.91	.72	1.43	2.67	1.84	1.22	[1]1.56	.11	......	[1].72
B. L. Hartwell, R. I. Station	......	[1]1.00	[1]1.64	[1]3.38	2.03	......	3.90	......	......	......
H. K. Miller, N. C. Station	.98	.70	1.47	2.90	1.92	1.30	3.36	.11	9.80	[1].70
	.99	.74	1.48	2.88	1.96	1.34	3.37	.13	9.86	.82
F. S. Shiver, S. C. Station	1.07	.79	[1]1.53	2.77	1.90	1.28	3.24	.06	9.80	.96
W. B. Ellett, Va. Station	1.12	.84	1.29	[1]2.46	1.83	1.51	2.85	[1].56	[1]9.06	1.04
	1.00	.76	1.34	[1]2.35	1.79	1.42	3.00	[1].58	[1]9.12	1.00
Average	1.04	.74	1.39	2.82	1.87	1.31	3.29	.09	9.73	.97

[1] Omitted from average.

As a whole, the results by this method are very good with one or two exceptions. One very discordant result obtained in leather may be explained by the following note by Dr. Wiley as to the manner in which the method was carried out in his laboratory:

> Inasmuch as our laboratory is in temporary quarters it was not possible to make the determination of pepsin-indigestible nitrogen in precisely the way specified in your circular of instructions. Our results obtained by this method are therefore lacking in value. It will be interesting, however, to note what difference this variation of method has caused in the results.
>
> The digestion period extended for a much longer time than you directed. The samples were weighed and placed in the water bath at 9 a. m. on Wednesday, and the heating was continued for eight hours on that day, when the flasks were removed from the water bath and placed in an ice box. On Thursday the flasks were returned to the water bath at 9 a. m. and the heating continued for eight hours, when they were returned to the ice box. On Friday the flasks were returned to the water bath and heated for seven hours, when they were again returned to the ice box. On Saturday morning the flasks were placed in the water bath and heated for one hour, when their contents were filtered and the determination completed according to your directions.
>
> The 2 cc portions of 10 per cent hydrochloric acid were added to the flasks at the end of the second and fifth hours as you directed. The portions which you directed to be added at the close of the eighth and eleventh hours were added on Thursday at 9 a. m. and at noon, respectively. You will note that the total period of digestion in the water bath is exactly twenty-four hours, as you directed, but that in addition to this the digestion proceeded for forty-nine hours while the flasks were contained in the ice box.

It is worthy of notice that, with the exception of the result in leather and a slight variation in blood, the results obtained under these conditions are excellent.

For convenience of comparison, the referee has calculated the per cent of availability by this method and the data obtained are given in Table No. III.

TABLE III.—*Availability of organic nitrogen.*

Analyst.	Dried blood.	Cottonseed meal.	Tankage.	Dried fish.	Meat scraps.	Castor pomace.	Steamed leather.	Bone meal.	Hoof meal.	Dried blood.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
O. W. Knight, Me. Station	88.85	91.13	[1]69.65	[1]97.13	[1]52.36	77.19	55.46	[1]39.59	[1]26.43	92.20
		91.91	[1]67.66	[1]97.61	[1]54.51	77.19	55.74	[1]39.59	[1]28.19	90.96
C. H. Jones and B. O. White, Vt. Station	88.24	90.90	76.40	65.95	59.91	77.13	53.50	98.15	35.72	92.27
T. C. Trescot, U. S. Dept. of Agr.	90.88	90.32	75.17	66.87	60.00	77.37	[1]77.42	97.12	Lost.	94.37
B. L. Hartwell, R. I. Station	......	[1]86.72	[1]72.16	[1]58.93	56.06	......	[1]43.72	......	......	......
H. K. Miller, N. C. Station	90.07	90.84	75.58	66.00	58.64	76.43	52.40	96.91	34.38	94.18
F. S. Shiver, S. C. Station	89.30	89.71	74.63	68.12	60.08	76.60	53.71	88.46	34.62	92.61
W. B. Ellett, Va. Station	89.23	89.35	77.40	71.10	60.31	[1]72.50	57.23	[1]85.00	37.79	92.15
Average	89.43	90.59	75.72	67.61	59.17	76.99	54.07	97.66	35.63	92.68
Vegetation cultures	68.00	74.00	61.00	69.00	......	72.77	13.80	64.00	67.00	90.30

[1] Omitted from average.

The variations noticed in the last table appear much more pronounced here. For instance, bone meal shows a variation in the last table of 0.53 per cent; this becomes in this table a variation of 13 per cent. But even taking this into consideration I do not think we could say that the results are good, and in some material it would appear that this method in the hands of different analysts will not give concordant results.

I should say, perhaps, in justice to the criticisms made in the last table, where it was stated that the results with few exceptions were good, that there appear in this table two sets of results which do not occur in the former one. In the case of blood the results are all that could be expected. Cottonseed meal and castor pomace are good. Dried fish gives an extreme variation of 39 per cent; bone gives 59 per cent, and leather gives 34 per cent. The hoof meal, meat scraps, and tankage are fair. The extreme variation occurring in hoof meal is about 11 per cent. Eliminating the results that cause such wide variation from the averages and comparing these averages with the results obtained by vegetation tests on materials of a similar character, they show very clearly, what is already known in regard to this method, that in such materials as hoof meal and leather it does not give their true availability.

The results obtained under vegetation cultures, except in the case of steamed leather and dried blood, are those obtained by Dr. Jenkins. In the case of leather and sample No. 10 of dried blood the results are from Dr. Wheeler.

(C) DIGESTION OF ORGANIC NITROGEN BY THE PERMANGANATE OF POTASH METHOD.

The pepsin method is exceedingly valuable as a means of detecting inferior forms of organic nitrogen; but one great objection to it is that it consumes a great deal of time, and also that it can not be relied upon entirely as a means of determining the true value of the various forms of nitrogen to plants.

The need, therefore, of a process that will determine quickly and more satisfactorily the availability of organic nitrogen as plant food has led to the suggestion that various solutions of potassium permanganate, alone or with the addition of acid or alkali, be used.

Considerable work was done on these methods last year by the referee and others, which tended to show them unsatisfactory in not giving concordant results. This seems to be the most serious objection.

If some modification of one of these methods can be devised by which this objection can be eliminated, that method would be a very valuable one, especially in regard to time, and from present indications would agree more closely with the vegetation tests than the pepsin method. In the following two tables are found the results obtained by the method proposed for trial this year. This method was suggested by the referee of last year, and is as follows:

Method: Place 1 gram of sample in a 150 cc flask, add 100 cc of a 2 per cent solution neutral permanganate of potash solution, and place in water bath for thirty minutes. The water bath is kept at the boiling point. At the end of the thirty minutes dilute and filter through a folded filter, wash several times, and determine nitrogen in residue by the Kjeldahl method.

TABLE IV.—*Percentage of nitrogen in residues after digestion with permanganate of potash.*

Analyst.	Dried blood.	Cottonseed meal.	Tankage.	Dried fish.	Meat scraps.	Castor pomace.	Steamed leather.	Bone meal.	Hoof meal.	Dried blood.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
F. Thompson, N. Y. Station	1.58	1.14	0.72	1.35	1.79	1.30	3.62 .56 .72	0.92	2.53 3.53 4.58	1.39
	1.59	1.15	.72	1.41	1.73	1.29	2.80 3.29 3.44	1.06	4.67 6.35 7.20	1.47
C. H. Jones and B. O. White, Vt. Station	.672	.77	.45	.80	.38	1.148	3.57	.966	.81	.69
T. C. Trescot, U. S. Dept. of Agr	.87	1.66	.42	1.46	1.09	1.18	3.26	.86	2.05	2.50
B. L. Hartwell, R. I. Station	.74	1.65	.47	.85	.32	.96	3.55	.56	......	.71
H. K. Miller, N. C. Station	1.06	1.50	.64	1.41	.63 .67 .91	1.32	3.74	1.64	2.88	1.87
	1.01	1.66	.78	1.20		1.29	3.64	1.47	2.47	2.10
J. P. Street, N. J. Station	1.28	1.88	.89	.99	.93	1.43	3.83	1.06	2.87	1.54
	1.29	1.71	.85	1.12	1.09	1.36	3.71	1.05	2.33	1.65
	1.28	1.79	.87	1.05	1.01	1.39	3.77	1.05	2.60	1.59
F. S. Shiver, S. C. Station	.31	.47	.23	.57	.04	.92	3.02	1.03	1.97	.59
W. B. Ellett, Va. Station	.70 .65 .78	1.85	.63	.89	.42	1.06	3.59	.95	1.84	.87
		1.40	.71	.78	.54	.92	3.35	.78	1.75	.86
A. T. Eskridge, Va. Station	.73	1.62	.60	.89	.44	1.06	3.53	.89	1.76	.90
	.67		.74	.71	.45	.89	3.48	.84	1.62	.80

TABLE V.—*Availability of nitrogen as determined by permanganate of potash.*

Analyst.	Dried blood.	Cottonseed meal.	Tankage.	Dried fish.	Meat scraps.	Castor pomace.	Steamed leather.	Bone meal.	Hoof meal.	Dried blood.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
A. J. Patten, Me. Station	91.83	91.63	89.75	90.20	87.65	77.66	55.01	64.96	80.73	89.90
	90.80	89.40	89.43	89.97	84.42	76.20	53.60	61.86		89.05
O. W. Knight, Me. Station	......	86.96	92.87	89.87	89.04	79.38	53.88	75.26	89.34	95.75
	92.65	85.66	91.21	85.44	89.04	81.57		76.82		96.83
F. Thompson, N. Y. Station	83.87	85.06	87.84	83.33	63.20	77.01	65.71	73.88	67.41	88.88
C. H. Jones and B. O. White, Vt. Station	93.20	89.98	92.13	90.48	91.54	78.26	49.07	74.41	94.57	94.67
T. C. Trescot, U. S. Dept. of Agr	91.28	77.69	92.71	81.89	76.30	78.10	52.82	77.49	86.04	80.44
B. L. Hartwell, R. I. Station	93.38	78.09	92.02	89.67	93.07	82.73	48.77	85.57	......	94.51
H. K. Miller, N. C. Station	89.57	79.26	88.61	84.70	88.25	76.79	47.88	60.05	82.11	84.75
J. P. Street, N. J. Station	86.90	76.10	85.00	87.40	76.80	75.80	45.10	72.70	82.30	87.40
F. S. Shiver, S. C. Station	96.90	93.88	96.19	93.45	99.16	83.18	56.86	73.52	86.85	95.46
W. B. Ellett, Va. Station	92.78	78.41	88.45	89.87	89.54	81.36	49.64	77.37	87.75	93.27
A. T. Eskridge, Va. Station	92.98	78.90	88.45	90.33	90.13	81.36	49.13	77.37	88.50	93.47

NOTES BY THE ANALYSTS.

A. J. Patten.—Heated the flasks half an hour in steam bath, shook them three times at intervals of ten minutes, washed with about 300 cc of hot water.

O. W. Knight.—In the permanganate method the residue was washed with 400 cc hot distilled water. The material was shaken three times at intervals of ten minutes during the digestion. Found the sample of dried blood very hard to wash after digestion.

L. L. Van Slyke.—The results in 7 and 9 are very variable. You notice that Mr. Thompson took all possible precaution to secure uniformity in treatment. In his hands the method is worthless for these materials.

H. W. Wiley.—In treating sample No. 7 by the permanganate of potash method, it was found at the end of the period of digestion that the permanganate color had been entirely destroyed. Therefore a second determination was made by this method of the indigestible nitrogen in this sample and also in No. 10; but in this case 200 cc of permanganate of potash solution were used instead of 100 cc. Using this large excess of permanganate of potash, the results were very much lowered, viz, 1.40 per cent for sample No. 7 and 0 85 per cent for sample No. 10. The 100 cc portion of permanganate was not entirely discolored in the case of sample No. 10, but the determination was repeated, using the larger quantity, because of the high percentage of indigestible nitrogen found. These results indicate that a variation in the excess of permanganate of potash used causes a very considerable variation in the results obtained.

B. L. Hartwell.—It was interesting to note that in some of the filtrates from the permanganate treatment the color of the permanganate had entirely disappeared. This was noticed in regard to numbers 2, 4, 7, and 10. The filtrate from the leather was brown, and upon testing it with diphenylamin I found that it gave no reaction for nitrates and nitrites. In this respect it differed from the filtrates in the case of the other materials.

H. K. Miller.—In the case of the No. 7, I noticed that all the permanganate was reduced, and then made a determination, using 150 cc instead of 100 cc, and obtained a lower result for nitrogen in the residue.

J. P. Street.—I found it very difficult to remove all the material from the small 150 cc flask, and I attribute my wide results in one or two cases to that exclusively. I also lost some of my leather determination, the flask being too small to allow for the expansion of the liquid in heating.

By an examination of Table IV, it will be seen that there is a great lack of agreement in the results obtained by the different analysts, and in some materials it seems almost impossible to obtain concordant results in the same laboratory.

The variations were so great in both of these tables that it was impossible to attempt to make up the averages. In one or two cases it might have been possible. In cottonseed meal there are thirteen determinations; of this number seven are within 6 per cent of each other, and six are within 3 per cent, but the variation between these two sets is 17 per cent.

If we should eliminate those results which show the greatest variation and average the others, the results would approximate more nearly to the vegetation tests on similar substances, and come nearer to the truth in regard to hoof meal and leather than the pepsin method.

It is possible that the great variation in the method is due to the fact that it is almost impossible to keep all the material down in the solution while the digestion is going on. Some of the substances have a tendency to rise to the top of the solution as soon as the action begins in the flask. If this be shaken down some particles are left on the sides, and these, of course, are not acted upon to the same extent as the rest of the substance. This was noticed especially in case of leather and castor pomace.

This tendency to rise in the flask caused the loss of several determinations of both of the materials in our laboratory, and Mr. J. P. Street reports that he lost several of his determinations in leather on this account. This caused Mr. Street to try the following modification of this method: Instead of the 150 cc flask he used a 500 cc, and carried out the digestion on a steam bath for thirty minutes. The other details were the same. He makes the following remarks in this modification: "As my results show, whether the flask is above the water bath or immersed in the boiling water seems to make little difference; in fact, the (B) results show a slightly higher availability."

These results are as follows:

Substance.	Insoluble nitrogen in permanganate solution.	Availability of nitrogen in permanganate solution.	Substance.	Insoluble nitrogen in permanganate solution.	Availability of nitrogen in permanganate solution.
	Per cent.	*Per cent.*		*Per cent.*	*Per cent.*
Dried blood	1.03, 1.03, 1.03	89.40	Castor pomace	1.54, 1.51, 1.52	73.60
Cottonseed meal	1.54, 1.43, 1.48	80.20	Steamed leather	3.21, 3.48, 3.34	51.30
Tankage	0.85, 0.88, 0.86	85.20	Bone meal	1.34, 1.30, 1.32	65.60
Dried fish	1.08, 1.31, 1.19	85.70	Hoof meal	2.25, 2.28, 2.26	84.60
Meat scrap	0.85, 0.93, 0.89	79.60	Dried blood	1.34, 1.22, 1.28	90.00

Mr. J. M. Bartlett, of the Maine Station, submitted the results of work done by this method in samples of fertilizers, as follows:

No. 1. A fertilizer in which one-half of the nitrogen is from blood and one-half from leather.
No. 2. A fertilizer in which one-half of the nitrogen is from blood and one-half from hoof and bone meal.
No. 3. A fertilizer containing considerable hair and wool.
Nos. 4, 5, 6, 7, and 8 are five samples of fertilizers analyzed in his laboratory.

Number of sample.	Total nitrogen.	Digestible nitrogen by permanganate method.	Number of sample.	Total nitrogen.	Digestible nitrogen by permanganate method.
	Per cent.	*Per cent.*		*Per cent.*	*Per cent.*
1	3.08	65.48, 67.53	5	1.71	76.61, 81.28
2	3.01	91.36, 89.36	6	3.14	81.84, 80.89
3	3.17	86.43, 90.53	7	4.12	94.17, 94.90
4	2.40	77.92, 77.08	8	4.47	93.74, 91.05

Nos. 1 and 2 were made up in the laboratory with dissolved South Carolina rock and the nitrogen from sources mentioned.

The presence of leather as a source of the nitrogen in No. 1 is very clearly brought out in the comparison of the results given in this table for Nos. 1 and 2.

There is another point in the manipulation of this method which it would be well to call attention to, and that is the filtering of the substance after digestion. Some filter very rapidly and well, others are very troublesome, and there is a tendency of the very fine particles to run through the filter. This was noticed in blood, and to some extent in leather and cottonseed meal. This would, of course, be another source of variation in the results.

The various difficulties that were encountered in working with this method, and also the time consumed in filtering and washing, etc., led the referee to try a modification of the alkaline-permanganate method in the hope that it might be possible to eliminate errors and also save time in manipulation. The plan was to use the same amounts of organic nitrogen with each determination instead of the same amount of material. The solution used consisted of 100 cc of a 3 per cent permanganate solution and 100 cc of a solution of sodium hydrate (containing 600 cc of a saturated solution of sodium hydrate in 1 liter). After the solutions had been added, the flasks were connected with the distilling apparatus and boiled very gently, without distilling any, for thirty minutes. At the end of this time the temperature was increased and the solution distilled as in regular nitrogen work.

Availability of organic nitrogen in alkaline permanganate solution using equal amounts of nitrogen.

Substance.	On a 7 per cent nitrogen basis and 3 per cent permanganate solution.		On a 5 per cent nitrogen basis and 3 per cent permanganate solution.		Availability by vegetation cultures.
	Soluble nitrogen.	Available nitrogen.	Soluble nitrogen.	Available nitrogen.	
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Dried blood	6.64	67.28	8.06	82.27	68.00
	6.93	70.21	8.12	81.66	
Cottonseed meal	3.30	43.42	5.04	66.30	74.00
	3.39	44.61	5.04	66.30	
Tankage	3.64	61.80	4.58	77.76	61.00
	3.40	57.72	4.52	76.74	
Dried fish	4.35	52.10	6.72	80.48	69.00
	4.05	48.50	6.56	78.56	
Meat scraps	3.08	66.67	3.59	77.71	....
	3.17	68.61	3.49	75.54	....
Castor pomace	4.06	74.91	4.66	85.98	72.77
	4.04	74.54	4.36	80.44	
Steamed leather	3.26	46.84	3.50	50.29	13.80
	3.02	43.40	3.60	51.72	
Bone meal	2.88	75.20	3.02	78.85	64.00
	2.32	60.60	3.14	81.98	
Hoof meal	11.71	79.01	11.98	80.84	67.00
	11.74	79.22	12.23	82.52	
Dried blood	9.46	73.22	10.36	80.19	90.30
	9.18	71.05	10.33	80.00	

Another series of determinations was run in the same manner, but a 2.5 per cent solution of permanganate was used and a smaller quantity of nitrogen employed.

In the following table are found the two series of results obtained by the modification.

The results in the series of the 3 per cent permanganate solution used were obtained by Mr. W. B. Ellett, and those when the 2.5 per cent solution was used were obtained by Mr. A. T. Eskridge.

The method gave very little trouble in carrying it out.

In one or two cases there was a little bumping at first, but this did not last long. So far as can be judged from the few determinations made, it appears to be possible to obtain good duplicates. The inability to do this has been the chief objection heretofore raised against the alkaline-permanganate method. Whilst the results do not agree very closely with the vegetation tests they do, with one exception (cottonseed meal), show the relative availability of the different forms of nitrogen.

With the results received from the Vermont Station there was also received from Mr. C. H. Jones a series of results obtained by a modification of the alkaline-permanganate method. The permanganate solution used by Mr. Jones consisted of 16 grams of potassium permanganate and 150 grams of sodium hydrate to the liter; 100 cc of this solution were used, and the digestion was for one hour at a temperature below the boiling point. At the end of that time the distillation was allowed to proceed for one hour. The quantity of material used in each case was on a basis of 4.5 per cent of nitrogen.

The results obtained by Mr. Jones are as follows:

Alkaline permanganate in a 4.5 per cent nitrogen basis.

Substance.	Nitrogen content.	Grams used.	Equivalent to nitrogen.	Nitrogen.	Availability.
	Per cent.		*Per cent.*	*Per cent.*	*Per cent.*
Dried blood	9.90	0.45	4.46	2.55	57.2
				2.58	57.8
Cottonseed meal	7.74	.55	4.49	2.08	46.3
				2.03	45.2
Tankage	5.71	.80	4.57	2.52	55.1
				2.59	56.7
Dried fish	8.36	.55	4.60	2.55	55.4
				2.60	56.6
Meat scraps	4.50	1.00	4.50	2.80	62.2
				2.90	64.4
Castor pomace	5.33	.85	4.53	2.47	54.5
				2.51	55.3
Steamed leather	7.00	.65	4.55	1.67	36.7
				1.74	38.[illegible]
Bone meal	3.82	1.20	4.58	3.18	69.4
				3.28	71.5
Hoof meal	14.93	.30	4.48	3.15	70.3
				3.15	70.3
Dried blood	13.08	.35	4.58	2.78	60.7
				2.80	61.1

Mr. Jones makes the following comment: "I send you the results obtained by a modification of the alkaline-permanganate method as applied to your samples. Fifty per cent is our dividing line; above 50 we call good and below 50 questionable. Cottonseed meal runs from 45 to 49, but pepsin-hydrochloric acid test at once gives a high availability, which points to the presence of cottonseed meal. Very few of our fertilizers contain cottonseed meal, and the modification need not be condemned simply because it fails on such material, but, as it is quicker as regards time than any of the others, its application can easily sort out all suspicious samples, and these can be tested by the [illegible]sin method."

These results obtained by the alkaline-permanganate method are exceedingly good, and tend to show that with a further study of it, especially in regard to the strength of the permanganate solution, it may probably become a reliable method.

(D) DIGESTION OF ORGANIC NITROGEN BY THE MODIFIED PEPSIN-HYDROCHLORIC ACID METHOD.

The method used in this case was one suggested to the referee by Mr. H. J. Patterson, of Maryland. It had been used by him in some digestion experiments in food stuffs in comparison with the regular pepsin method, and he found it gave more concordant results than the pepsin.

It was recommended for trial in order to see if it could be used in work of this kind, and also whether it had any advantage over our regular pepsin method in obtaining better results or in ease of manipulation.

Method: Place 2 grams of sample in a 150 cc flask; add 100 cc of a 0.33 per cent hydrochloric acid solution; add to the solution 0.1 gram of Parke, Davis & Co.'s pulverized pepsin. The flasks are then kept for twelve hours closely corked in a water bath, having a constant temperature of 40° C., with occasional shaking. At the end of the twelve hours the contents are filtered, washed until free from acid, returned to the flask with 100 cc of water, 0.15 gram pancreatin (Merck's), and 0.3 gram of sodium carbonate added, and the whole heated again for twelve hours at 40° C., with occasional shaking. The residue is filtered, thoroughly washed, and the nitrogen determined by the Kjeldahl method.

The results obtained by this method are given in Table VI.

TABLE VI.—*Organic nitrogen insoluble in modified pepsin solution.*

Analyst.	Dried blood.	Cottonseed meal.	Tankage.	Dried fish.	Meat scraps.	Castor pomace.	Steamed leather.	Bone meal.	Hoof meal.	Dried blood.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
C. H. Jones and B. O. White, Vt. Station	0.81	0.18	1.43	2.73	1.65	1.11	0.46	2.28	6.85	0.53
	.67	.25	1.30	2.76	1.62	1.13	.49	2.24	7.70	.51
F. S. Shiver, S. C. Station	.48	.16	1.24	2.18	1.32	1.09	.31	1.74	7.97	.54
A. T. Eskridge, Va. Station	.88	.27	1.00	2.65	1.51	.94	.44	1.93	8.48	.59
	.63	.28	.95	2.74	1.65	.85	.60	1.92	8.49	.66

Availability of organic nitrogen in modified pepsin solution.

Analyst.	Dried blood.	Cottonseed meal.	Tankage.	Dried fish.	Meat scraps.	Castor pomace.	Steamed leather.	Bone meal.	Hoof meal.	Dried blood.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
C. H. Jones and B. O. White, Vt. Station	92.49	97.14	76.05	67.26	64.59	79.01	93.15	40.37	51.21	95.98
F. S. Shiver, S. C. Station	95.20	97.92	79.44	74.91	72.27	80.07	95.57	55.27	46.83	96.15
A. T. Eskridge, Va. Station	92.38	96.35	83.10	67.35	65.35	83.05	92.46	49.21	42.24	95.16

Results by this method were received from only three analysts, so that perhaps we are not justified in criticising it.

The results obtained agree fairly well and compare favorably with the regular pepsin method, except in case of leather. With this substance the method is worthless, especially on account of the action of sodium carbonate on leather. In addition to this serious objection, the method is not likely to be used very often on account of the trouble of manipulation, requiring, as it does, two digestion periods of twelve hours each, making it very inconvenient to attend to, and also two filterings. The filtering is very slow, in some cases requiring two or three filters and one or two days' time.

This subject of the availability of organic nitrogen has been very thoroughly studied at the Vermont Station, a large amount of work having been done with the permanganate of potash method, especially the alkaline permanganate.

The materials used represent samples from nearly all the sources of organic nitrogen, as well as samples of fertilizers containing various mixtures. The results of these investigations are published in the last annual report of the station. A copy of this part of the report is at hand and can be seen by anyone wishing to do so.

The only recommendation which your referee wishes to make on the subject is that the permanganate of potash methods for the determination of the availability of organic nitrogen be further studied next year, especially some modification of the alkaline-permanganate method.

After twenty-four hours digestion, filter, wash four or five times, using 20 to 30 cc of water for each washing, and determine nitrogen by the Kjeldahl method in the washed and dried residue.

PERMANGANATE OF POTASH METHOD.

Weigh 1 gram of sample into a 150 cc flask, add 100 cc of a 2 per cent neutral permanganate of potash solution, and place in a water bath for thirty minutes. The water bath is kept at the boiling point. At the end of the thirty minutes dilute and filter through a folded filter, wash several times, and determine nitrogen in residue by Kjeldahl method.

MODIFIED PEPSIN-HYDROCHLORIC ACID METHOD.

Weigh 2 grams of sample into a 150 cc flask, add 100 cc of a 0.33 per cent hydrochloric acid solution; add to this 0.1 gram of scale pepsin. The flasks are then kept for twelve hours loosely corked in a water bath having a constant temperature of 40° C., with occasional shaking. At the end of the twelve hours the contents are filtered, washed until free from acid, returned to the flask with 100 cc of water, 0.15 gram pancreatin (Merck's), and 0.3 gram of sodium carbonate added, and the whole heated again for twelve hours at 40° C., with occasional shaking. The residue is filtered, thoroughly washed, and the nitrogen determined by the Kjeldahl method.

At the conclusion of the reading of the report the president called for any paper on the subject. None being offered, the discussion of the subject was declared to be in order.

Mr. C. H. Jones reported results of his experiments in leather, dried blood, etc. His experience led him to believe that the nitrogen in leather in commercial fertilizers could not be detected in quantities of less than 2 per cent. When leather is treated with sulphuric acid, which is the usual custom before mixing it in fertilizers, its texture is practically destroyed so as to render its detection extremely difficult. He thought the permanganate method valuable in showing those samples which fall below 50 per cent of available nitrogen, and these could be set aside for further testing with the pepsin method.

Mr. H. J. Wheeler stated that in comparative tests of the availability of leather and dried blood in vegetation experiments he had found that about 19 per cent of the leather and 90 per cent of the blood were available for plant nutrition.

Mr. Jones thought it was hardly reasonable to require a method which would give the same results as vegetation experiments.

Mr. J. A. Myers asked Mr. Wheeler if there were any means of determining the degree of pulverization of the leather.

Mr. Wheeler replied that it was difficult to determine the degree of pulverization of the leather. There should not be so great a discrepancy between the methods. This sample was further pulverized before it was sent out, but in the vegetation tests it was not pulverized.

The PRESIDENT. The recommendations of the referee on nitrogen will be referred to the committee.

The president then called for the report of the referee on potash. The report was read by the referee, Mr. C. H. Jones.

REPORT ON POTASH.

By C. H. JONES, *Referee*, and B. B. ROSS, *Associate Referee*.

The methods for estimating potash have been quite thoroughly studied by this association in years past, so far as potash salts and fertilizers are concerned. The applicability of these methods to wood ashes and cotton-hull ashes being deemed of considerable importance, the referee for 1898 was directed to investigate our present methods for determining K_2O as applied to these materials.

PREPARATION OF SAMPLES.

Two samples were accordingly prepared; No. 1, consisting of high grade wood ashes obtained from Waterbury Center, Vt.. and No. 2, cotton-hull ashes from a Connecticut dealer. Particular care was used in collecting and storing the ashes from which No. 1 was taken, and results show this must have been the case. A lower grade sample containing more silicate of potash would have been preferable for our work.

The finely ground samples were carefully and independently mixed by two men, and then bottled and sealed. Three samples from each lot, selected at random after bottling, were analyzed in the Vermont laboratory. The uniform results obtained would indicate perfect mixing of the original materials.

DIRECTIONS FOR WORK.

Under date of January 24, 1898, circular letters were sent to interested parties, stating scope of work and requesting cooperation. Favorable replies were received from twenty chemists and samples were sent them with instructions as follows:

AGRICULTURAL EXPERIMENT STATION, *Burlington, Vt.*

DEAR SIR: At the last meeting of the Association of Official Agricultural Chemists, the referee on potash was directed to test our present methods for determining potash as applied to wood ashes and cotton-hull ashes.

Under separate cover we send you by mail samples Nos. 1 and 2. You are requested to determine the potash in them, following instructions here given.

Determine moisture on 2 grams of the material as per page 11, Bulletin 46, United States Department of Agriculture, Division of Chemistry.

1. *Water soluble potash.*—(*a*) Determine according to the Lindo-Gladding method for fertilizers described on page 2, Circular No. 4, United States Department of Agriculture, Division of Chemistry.

(*b*) Determine as per optional method on pages 2 and 3 of Circular No. 4.

2. *Acid soluble potash.*—(*a*) Method of making solution: Place 5 grams of the material in a 250 cc flask, moisten with about 20 cc H_2O, and cautiously add 20 cc of HCl, sp. gr. 1.20. When the CO_2 is nearly expelled add about 50 cc of H_2O and boil for 30 minutes.

(*b*) Partially cool, add slight excess of ammonia and sufficient powdered ammonium oxalate to precipitate all the lime present. Cool and make to 250 cc. Filter through a dry filter and determine K_2O as per Lindo-Gladding method, page 2, Circular No. 4.

(*c*) Make solution as just directed by treating 5 grams of the material with HCl and boiling. Do not add ammonia and ammonium oxalate. Dilute with H_2O, cool, and make to volume of 250 cc. Filter through a dry filter and determine K_2O as under the optional method, page 3, Circular No. 4, using 25 cc of the solution.

3. Make blank determinations on reagents, using amounts as required in the actual analysis.

4. Owing to the danger of the final K_2PtCl_6 being contaminated with silicic acid you are requested to make sure that the K_2PtCl_6 obtained is soluble in water, by dissolving the salt, drying and reweighing the crucible. Use Gooch crucibles for filtering the K_2PtCl_6.

5. In reporting results kindly state (1) amount of material employed, (2) total weight of K_2PtCl_6 found, (3) weight of K_2PtCl_6 from reagents, (4) increase due to silicic acid, if any, (5) per cent of moisture found.

Report results not later than September 1, 1898.

Yours, truly,

C. H. JONES, *Referee*.
B. B. ROSS, *Associate*.

RESULTS OBTAINED.

Results have been received from the following chemists: Mr. A. W. Ogden, Experiment Station, New Haven, Conn.; Mr. C. C. McDonnell, Mr. John Thompson, and Mr. F. S. Shiver, Clemson College, South Carolina; Mr. F. P. Veitch, College Park, Md.; Mr. G. E. Patrick, United States Department of Agriculture, Washington, D. C.; Mr. Walker Bowman, chemist for the Louisville Spirit-Cured Tobacco Company, Louisville, Ky.; Mr. B. O. White and Mr. C. H. Jones, Vermont Experiment Station, Burlington, Vt.

The following table shows in detail the results obtained. The percentage of K_2O was calculated in all cases by the referee using the factor .1939. In no case was correction made for bulk of undissolved and precipitated material.

Results of potash work for 1898.

WATER SOLUBLE POTASH, WOOD ASHES, No. 1.

Analyst.	Moisture.	Quantity used.	K_2PtCl_6 and impurities.		K_2PtCl_6 in reagents.		Increase due to silica, etc.		Corrected weight, K_2PtCl_6		Potassium oxid.	
			Lindo-Gladding.	Optional.	Lindo-Gladding.	Optional.	Lindo-Gladding.	Optional.	Lindo-Gladding.	Optional.	Lindo-Gladding.	Optional.
	P.ct.	*Gr.*	*Gr.*	*Gr.*	*Gr.*	*Gr.*	*Gr.*	*Gr.*	*Gr.*	*Gr.*	*P.ct.*	*P.ct.*
A. W. Ogden, New Haven, Conn	0.18	1	0.4855	0.4879	0.0000	0.0026	0.0006	0.0010	0.4849	0.4843	9.40	9.39
	.18	1	.4851	.4888	.0000	.0026	.0005	.0020	.4846	.4842	9.40	9.39
C. C. McDonnell, Clemson College, S. C	.29	1	.4836	[1] .2601	.0003	.0198	(2)	......	.4833	[1] .2403	9.37	9.32
John Thompson, Clemson College, S. C	.26	½	.2406	.2475	.0003	.0056	.0014	.0009	.2389	.2410	9.26	9.34
F. S. Shiver, Clemson College, S. C	.21	½	.2470	.2692	.0029	.0254	.0045	.0039	.2396	.2399	9.29	9.30
F. P. Veitch, College Park, Md	.07	1	.4863	......	.0020	......	......	......	.4843	......	9.39	......
	.08	1	.4889	......	.0020	......	......	......	.4869	......	9.44	......
B. O. White, Burlington, Vt.	.30	1	.4858	......	.0000	......	.0010	......	.4848	......	9.40	......
	.26	1	.4842	......	.0000	......	.0005	......	.4837	......	9.38	......
C. H. Jones, Burlington, Vt.	.27	1	.4850	.4893	.0000	.0056	.0000	.0016	.4850	.4821	9.40	9.35
	.25	1	.4860	.4922	.0000	.0056	.0005	.0012	.4855	.4854	9.41	9.41
G. E. Patrick, Washington, D. C	[3] .02	1	.4889	.5080	.0011	.0080	......	......	.4878	.5000	9.46	[4] 9.69
	[3] .10	1	.4875	......	.0011	......	......	......	.4864	......	9.43	......
Walker Bowman, Louisville, Ky	.22	1	[5] .4536	[5] .4895	.0000	.0277	......	......	[5] .4536	[5] .4618	[4] 8.79	[4] 8.95
Average	......	......	......	......	......	......	......	......	......	......	9.39	9.36

WATER SOLUBLE POTASH, COTTON-HULL ASHES, No. 2.

Analyst.	Moisture.	Quantity used.	K_2PtCl_6 and impurities.		K_2PtCl_6 in reagents.		Increase due to silica, etc.		Corrected weight, K_2PtCl_6		Potassium oxid.	
			Lindo-Gladding.	Optional.	Lindo-Gladding.	Optional.	Lindo-Gladding.	Optional.	Lindo-Gladding.	Optional.	Lindo-Gladding.	Optional.
A. W. Ogden, New Haven, Conn	4.51	½	0.4344	0.4412	0.0000	0.0026	0.0000	0.0635	0.4344	0.4351	16.84	16.87
	4.46	½	.4361	.4385	.0000	.0026	.0000	.0020	.4361	.4339	16.91	16.82
C. C. McDonnell, Clemson College, S. C	4.17	½	.4291	.4508	.0003	.0198	(2)	......	.4288	.4310	16.63	16.72
John Thompson, Clemson College, S. C	4.30	½	.4308	.4357	.0003	.0056	.0010	.0012	.4295	.4289	16.65	16.64

[1] One-half gram material used.

[2] Filtered before adding K_2PtCl_6.

[3] After 5½ hours' drying.

[4] Omitted from average.

[5] Results calculated to a 1 gram basis by referee.

Results of potash work for 1898—Continued.

WATER SOLUBLE POTASH, COTTON-HULL ASHES, No. 2—Continued.

Analyst.	Moisture.	Quantity used.	K_2PtCl_6 and impurities.		K_2PtCl_6 in reagents.		Increase due to silica, etc.		Corrected weight, K_2PtCl_6		Potassium oxid.	
			Lindo-Gladding.	Optional.	Lindo-Gladding.	Optional.	Lindo-Gladding.	Optional.	Lindo-Gladding.	Optional.	Lindo-Gladding.	Optional.
	P. ct.	*Gr.*	*Gr.*	*Gr.*	*Gr.*	*Gr.*	*Gr.*	*Gr.*	*Gr.*	*Gr.*	*P. ct.*	*P. ct.*
F. S. Shiver, Clemson College, S. C	4.72	½	.4388	.4582	.0020	.0169	.0000	.0035	.4368	.4378	16.94	16.98
F. P. Veitch, College Park, Md	[1]3.92	½	.4675	......	.0020	......	......	......	.4655	......	[2]18.05	......
	[1]4.00	½	.4650	......	.0020	......	......	......	.4630	......	[2]17.95	......
B. O. White, Burlington, Vt	4.28	½	.4364	......	.0000	......	.0000	......	.4364	......	16.92	......
	4.34	½	.4330	......	.0000	......	.0000	......	.4330	......	16.79	......
C. H. Jones, Burlington, Vt	4.45	½	.4360	.4398	.0000	.0056	.0000	.0014	.4360	.4328	16.91	16.78
	4.42	½	.4350	.4428	.0000	.0056	.0005	.0020	.4345	.4352	16.85	16.88
G. E. Patrick, Washington, D. C	[3]4.25	1	.9187	(4)	.0011	......	......	......	.9176	(4)	[2]17.79	......
	[3]4.20	1	.9220	......	.0011	......	......	......	.9209	......	[2]17.85	......
Walker Bowman, Louisville, Ky	0.88	1	[5].8228	[5].8531	.0000	.0482	......	......	[5].8228	[5].8049	[2]15.95	[2]15.60
Average	......	......	......	......	......	......	......	......	......	......	16.83	16.81

ACID SOLUBLE POTASH, WOOD ASHES, No. 1.

Analyst.	Moisture.	Quantity used.	K_2PtCl_6 and impurities.		K_2PtCl_6 in reagents.		Increase due to silica, etc.		Corrected weight, K_2PtCl_6		Potassium oxid.	
			Lindo-Gladding.	Optional.	Lindo-Gladding.	Optional.	Lindo-Gladding.	Optional.	Lindo-Gladding.	Optional.	Lindo-Gladding.	Optional.
A. W. Ogden, New Haven, Conn	0.18	1	0.5113	0.5164	0.0000	0.0026	0.0000	0.0017	0.5113	0.5121	9.91	9.93
	.18	1	.5135	.5156	.0000	.0026	.0000	.0017	.5135	.5113	9.96	9.91
C. C. McDonnell, Clemson College, S. C	.29	½	.2568	.2733	.0003	.0151	(6)	......	.2565	.2582	9.95	10.01
John Thompson, Clemson College, S. C	.26	½	.2605	.2680	.0003	.0065	.0014	.0010	.2588	.2605	10.03	10.10
F. S. Shiver, Clemson College, S. C	.21	½	.2675	.2916	.0044	.0325	.0056	.0053	.2575	.2538	9.98	9.84
F. P. Veitch, College Park, Md	.07	1	.5012	......	.0020	......	.0000	......	.4992	......	9.68	......
	.08	1	.4974	......	.0020	......	.0000	......	.4954	......	9.61	......
B. O. White, Burlington, Vt	.30	½	.2572	......	.0000	......	.0000	......	.2572	......	9.97	......
	.26	1	.5125	......	.0000	......	.0000	......	.5125	......	9.94	......
C. H. Jones, Burlington, Vt	.27	½	.2555	......	.0000	......	.0000	......	.2555	......	9.91	......
	.25	1	.5152	.5237	.0000	.0091	.0000	.0015	.5152	.5131	9.99	9.95
	......	1	......	.5229	......	.0091	......	.0022	......	.5116	......	9.92
G. E. Patrick, Washington, D. C	[3].02	1	.4935	.5116	.0011	.0118	......	......	.4924	.4998	[2]9.54	9.69
	[3].10	1	.4916	......	.0011	......	......	......	.4905	......	[2]9.51	......
Walker Bowman, Louisville, Ky	.22	1	[5].4688	[5].5110	.0000	.0283	......	......	[5].4688	[5].4827	[2]9.09	[2]9.36
Average	......	......	......	......	......	......	......	......	......	......	9.90	9.92

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[1] At end of ten five-hour periods of drying found 5.12 and 5.17 per cent moisture.
[2] Omitted from average.
[3] After 5½ hours' drying.
[4] Results unsatisfactory and no time to repeat.
[5] Results calculated to a 1 gram basis by referee.
[6] Filtered before adding K_2PtCl_6.

Results of potash work for 1898—Continued.

ACID SOLUBLE POTASH, COTTON-HULL ASHES, No. 2.

Analyst.	Moisture.	Quantity used.	K_2PtCl_6 and impurities.		K_2PtCl_6 in reagents.		Increase due to silica, etc.		Corrected weight, K_2PtCl_6		Potassium oxid.	
			Lindo-Gladding.	Optional.	Lindo-Gladding.	Optional.	Lindo-Gladding.	Optional.	Lindo-Gladding.	Optional.	Lindo-Gladding.	Optional.
	P. ct.	*Gr.*	*Gr.*	*Gr.*	*Gr.*	*Gr.*	*Gr.*	*Gr.*	*Gr.*	*Gr.*	*P. ct.*	*P. ct.*
A. W. Ogden, New Haven, Conn	4.51	½	0.5420	0.5423	0.0000	0.0026	0.0010	0.0009	0.5410	0.5388	20.98	20.90
	4.46	½	.5431	.5434	.0000	.0026	.0006	.0002	.5425	.5406	21.04	20.96
C. C. McDonnell, Clemson College, S. C	4.17	½	.5434	.5615	.0003	.0151	(1)	......	.5431	.5464	21.07	21.19
John Thompson, Clemson College, S. C	4.30	½	.5475	.5549	.0003	.0065	.0012	.0012	.5460	.5472	21.17	21.22
F. S. Shiver, Clemson College, S. C	4.72	½	.5456	.5804	.0038	.0325	.0012	.0049	.5406	.5430	20.96	21.06
F. P. Veitch, College Park, Md	[2]3.92	½	.5365	......	.0020	......	.0129	......	.5216	......	[3]20.23	......
	[2]4.00	½	.5370	......	.0020	......	.0129	......	.5221	......	[3]20.25	......
	......	½	.5318	......	.0020	......	.0129	......	.5169	......	[3]20.05	......
B. O. White, Burlington, Vt.	4.28	½	.5395	......	.0000	......	.0006	......	.5389	......	20.90	......
	4.34	½	.5436	......	.0000	......	.0012	......	.5424	......	21.03	......
C. H. Jones, Burlington, Vt	4.45	½	.5425	.5517	.0000	.0091	.0000	.0012	.5425	.5404	21.04	20.95
	4.42	½	.5448	.5490	.0000	.0091	.0010	.0008	.5438	.5391	21.08	20.91
G. E. Patrick, Washington, D. C	[4]4.25	1	1.0927	1.0952	.0011	.0118	......	......	1.0916	1.0834	21.16	21.01
	[4]4.20	1	1.0946	......	.0011	......	......	......	1.0935	......	21.20	......
Walker Bowman, Louisville, Ky	.88	½	[5].5100	[5].5190	.0000	.0233	......	......	[5].5100	[5].4957	[5]19.78	[5]19.22
Average	......	......	......	......	......	......	......	......	......	......	21.06	21.03

[1] Filtered before adding K_2PtCl_6.
[2] At end of ten five-hour periods of drying found 5.12 and 5.17 per cent moisture.
[3] Omitted from average.
[4] After 5½ hours' drying.
[5] Calculated to one-half gram basis by referee.

COMMENTS BY THE REFEREE.

A comparison of the average results by both methods shows practically no difference, the extreme variation being only 0.03 per cent. Forty-four results are used in making the averages for the Lindo-Gladding method, and thirty for the optional.

Under water soluble potash No. 1, thirteen out of fourteen results by the Lindo-Gladding method vary but 0.20 per cent (9.26–9.46 per cent, with an average of 9.39 per cent). Seven out of nine results by the optional method agree closely with each other, the variations being but 0.11 per cent (9.30–9.41 per cent, average 9.36 per cent).

In sample No. 2 the variations by each method are larger than in the preceding case. Nine out of fourteen give an average of 16.83 per cent by the Lindo-Gladding method; highest 16.94, lowest 16.63 per cent, difference 0.31 per cent K_2O; while by the optional seven out of eight show a variation of 0.34 per cent, highest 16.98, lowest 16.64 per cent, average 16.81 per cent K_2O.

The acid soluble potash results show far more uniformity than was expected. With No. 1, eleven out of fourteen agree within 0.42 per cent K_2O (9.61–10.03 per cent, average 9.90 per cent K_2O) by the Lindo-Gladding method, and within 0 41 by the optional (9.69–10.10 per cent, average 9.92 per cent K_2O).

No. 2, Lindo-Gladding method, shows eleven out of fifteen to vary 0.30 per cent (20.90-21.20 per cent, average 21.06 per cent K_2O). Optional method, eight out of nine vary 0.32 per cent; highest 21.22 per cent, lowest 20.90 per cent, average 21.03 per cent K_2O.

Table summarizing the foregoing data.

	Lindo Gladding.					Optional.					Average per cent K_2O.	
	Number of results received.	Number averaged.	Highest per cent K_2O.	Lowest per cent K_2O.	Extreme variation, per cent K_2O.	Number of results received.	Number averaged.	Highest per cent K_2O.	Lowest per cent K_2O.	Extreme variation, per cent K_2O.	Lindo-Gladding.	Optional.
Wood ashes, water soluble potash	14	13	9.46	9.26	0.20	9	7	9.41	9.30	0.11	9.39	9.36
Cotton-hull ashes, water soluble potash	14	9	16.94	16.63	.31	8	7	16.98	16.64	.34	16.83	16.81
Wood ashes, acid soluble potash	14	11	10.03	9.61	.42	9	8	10.10	9.69	.41	9.90	9.92
Cotton-hull ashes, acid soluble potash	15	11	21.20	20.90	.30	9	8	21.22	20.90	.32	21.06	21 03

The chemist reporting low results throughout apparently did not follow the prescribed methods. It is also to be regretted that the high results by the Lindo-Gladding method on sample No. 2 were not checked by the optional method. In one case it was not attempted, and in the other unsatisfactory results were reported with no time to repeat.

Your attention is now directed to the columns showing corrections made, both because of potash in reagents used and of increase due to silica, etc. The former, in the case of the Lindo-Gladding method, sample No. 1, shows an extreme of 8.8 mg K_2PtCl_6, equivalent to 0.17 per cent K_2O, and in No. 2 of 7.6 mg K_2PtC_6, or 0.15 per cent K_2O. The latter furnishes an insoluble residue correction varying from nothing to 11.2 mg K_2PtCl_6, or 0.22 per cent K_2O, if we except the results of one chemist whose large correction seems to be due to an insufficient washing in the final dissolving of the potassium salt.

When the optional method was used the K_2PtCl_6 found in reagents varied from 2.6 to 65 mg, or from .05 to 1.26 per cent K_2O. The same tendency toward large corrections has been observed in past years when this method has been employed. The increase due to silica, etc., by the optional method does not differ materially from that obtained by the Lindo-Gladding.

DIRECT EVAPORATION WITH K_2PtCl_6.

It was suggested to your referee last year by Mr. Winton that good results might be obtained in water soluble potash determinations on materials similar to those under consideration, by directly evaporating the water solution, without the addition of NH_4OH and $(NH_4)_2C_2O_4$, with K_2PtCl_6, the final precipitate being washed with NH_4Cl solution as usual. A similar method of procedure was adopted for the analysis of kainit at our 1897 meeting.

Mr. Ogden, of the Connecticut Station, kindly sent results by this method, which, together with those obtained by Mr. White and myself, are found in the following table:

Results in determination of potash.

Analyst.	No. 1.			No. 2.		
	Grams used.	K_2PtCl_6 found.	K_2O found.	Grams used.	K_2PtCl_6 found.	K_2O found.
		Grams.	*Per cent.*		*Grams.*	*Per cent.*
A. W. Ogden, Connecticut	1	0.4878	9.46	½	0.4342 .4353	16.84 16.88
B. O. White, Vermont	1	.4860	9.42	½	.4362	16.91
C. H. Jones, Vermont	1	.4855	9.41	½	.4347	16.86

MOISTURE DETERMINATIONS.

Some interesting data were furnished under this head by Mr. G. E. Patrick, who found the loss of moisture after five hours' drying to be 0.02 and 0.10 per cent with sample No. 1. Continued drying showed a gradual increase in weight, due doubtless to absorption of CO_2, until after forty-one hours' drying, gains in weight of 1.11 and 1.07 per cent were recorded.

The same chemist, with sample No. 2, observed a gradual loss in weight, and the moisture percentages at the end of forty-one hours' drying were 7.28 and 7.17.

A similar behavior with No. 1 was observed in the Vermont laboratory, but the drying was not carried so far. Our reported results represent the loss after five hours' drying at 100° C. and continued heating for one hour did not change them.

CHLORIN IN FERTILIZERS.

A second duty of the referee was to investigate methods for determining chlorin This, as I understand it, refers to a quick and reliable means of ascertaining whether or not the potash present in fertilizers is in the form of chlorid, or agriculturally what amounts to the same thing, whether sufficient chlorin exists in the material to account for all the potash as such.

From conversation with members of this association in 1897, I learned that among the methods in use was the volumetric estimation of the chlorin by standard $AgNO_3$ in an aliquot of the soluble phosphoric acid solution, or in solutions specially prepared, and the regular gravimetric method.

I desire to present for your consideration a method which was introduced in our laboratory by Mr. Hills in the spring of 1896. With a slight modification it has been used, successfully, we think, for the past three seasons on all our commercial fertilizer samples. It consists in adding to 50 cc of the Lindo-Gladding potash solution (equivalent to 1 gram material) an excess of HNO_3 and as many cc of an $AgNO_3$ solution (1 cc of which corresponds to the chlorin equivalent to 1 per cent of K_2O on a basis of 1 gram material) as the percentage of K_2O found exceeds 0.5 per cent. The solution is boiled for about five minutes and stirred as in the regular chlorin determination. The precipitated AgCl is allowed to settle and a small portion of the supernatant liquid is decanted into a test tube. This is roughly divided into two portions; to one is added a tiny fragment of crystalline $AgNO_3$, to the other a few drops of dilute HCl or NH_4Cl solution. A precipitate in the first case indicates an excess of chlorin, even for 0.5 per cent more K_2O than the amount already found to be present, while a precipitate in the second shows an excess of $AgNO_3$, and consequently an insufficiency of chlorin. In the latter case, which with us amounted to less than 20 per cent of the entire number of fertilizers collected in 1898, the AgCl is filtered through a tared Gooch crucible, washed, dried, and weighed as usual. The weight of AgCl × 100 ÷ 3 gives the per cent of K_2O present as chlorid and is sufficiently accurate for general purposes.

The $AgNO_3$ solution is prepared by dissolving 36.17 grams of c. p. crystalline $AgNO_3$ in water and making to bulk of one liter.

To test the accuracy of the method three fertilizer mixtures were prepared. No. 1 contained potash in the form of common high-grade sulphate, No. 2 had its potash in the form of muriate, and No. 3 contained 4 parts of muriate and 6 parts of sulphate.

Analysis showed them to contain: No. 1, 4.24 per cent; No. 2, 4.40 per cent, and No. 3, 4.32 per cent of K_2O. $AgNO_3$ solution added, in cc equivalent to the above percentages of K_2O, to 50 cc of the Lindo-Gladding solution, treated as directed, filtered, dried, and weighed, gave weights of AgCl corresponding to 0.54 per cent, 4.25 per cent, and 2.64 per cent, respectively, of K_2O as chlorid or perhaps chlorin in other combinations sufficient to account for the equivalent of K_2O just stated. Tested qualitatively as per method, No. 2 showed an excess, while Nos. 1 and 3 an insufficiency of chlorin. The total chlorin in No. 2 amounted to an equivalent of 5.71 per cent K_2O.

This method has the merit of great rapidity and, for the purposes stated, is sufficiently accurate, quickly disposing of the vast majority of samples containing an excess of chlorin, the only question in most cases being simply this: Is there or is there not an amount of chlorin present equivalent to the potash percentage found?

We have tested, so far as time and opportunity would permit, the volumetric titration of chlorin in (1) soluble phosphoric acid, (2) Lindo-Gladding potash, and (3) specially prepared water solutions. Results have, as a rule, been satisfactory, but far more time and attention were required than when the method previously stated was used.

RECOMMENDATIONS.

I would recommend that the Lindo-Gladding method be adopted for determining water soluble potash in wood ashes and cotton-hull ashes, special attention being paid to the words, "The precipitate should be perfectly soluble in water," found in the description of this method, page 2, Circular No. 4, United States Department of Agriculture, Division of Chemistry.

I would also suggest that Gooch crucibles be used for filtering the K_2PtCl_6 when the Lindo-Gladding method is employed.

It is the opinion of your referee that the optional method should not be used unless blank determinations on reagents are made along with it.

At the conclusion of the reading of the report of the referee on potash, the president called for papers. None being presented, the general discussion was in order.

Mr. B. B. Ross called attention to his experience with asbestos and Gooch filters, to the effect that asbestos is attacked slightly by ammonium chlorid solution.

Mr. Jones replied that when asbestos had been previously treated with hydrochloric acid no loss from ammonium chlorid solution had been noticed, but some fibers may be carried through mechanically.

Mr. Ross stated that he used an ashless filter.

Mr. Wheeler asked Mr. Ross how he treated his asbestos before using it for filtering purposes.

Mr. Ross described his method of preparing the asbestos.

Mr. J. L. Hills suggested that manufactured asbestos paper might perhaps be used for filtering purposes.

Mr. Ross stated that he had used three or four different samples of this paper and always found that it suffered loss. He hoped other members would try this further.

After some discussion of the subject of asbestos felt and filters, the president stated that there were still ten minutes and perhaps there would be time for some miscellaneous business.

The secretary made announcements in regard to local arrangements for the entertainment of the members, and especially that the Cosmos Club had extended its courtesies to the members of the convention during the time of their stay here. He asked the members to make the Cosmos Club their headquarters, where they would find stationery, newspapers and magazines, and other comforts of life.

The president called upon Dr. Wheeler to report what action had been taken by him and his associates in regard to the criticism of the methods of potash analysis of our association on the part of certain German chemists.

Dr. Wheeler reported that he had offered an article to Dr. Nobbe, editor of the Versuchsstationen Journal, but he had not received any response. He had also called upon Dr. Nobbe during the past summer. It was evident it was not desired to publish the article in the Journal of the Versuchsstationen. He and his associates, therefore, thought it wise to offer it to The Chemical News, where it had been published, and copies of the reprint could be had by members of the association.

The reprints were distributed to such members of the association as desired them.

At the conclusion of Dr. Wheeler's oral report on this subject, the association adjourned for luncheon.

FRIDAY—AFTERNOON SESSION.

On the reassembling of the association, the president called for the report of the referee on phosphoric acid. Mr. B. W. Kilgore presented the following report:

REPORT ON PHOSPHORIC ACID.

By B. W. Kilgore, *Referee.*

The main object of the work on phosphoric acid the past year has been to further test the volumetric method, which this association has had under consideration for several years, in comparison with the official gravimetric one for the estimation of phosphoric acid in various materials. A second object of the work was a test of the Wagner citrate method for the estimation of available phosphoric acid in slag meals. So few results were received on the latter subject that it is not considered worth while to report them. The present report is therefore limited to the first named subject.

Five samples, with the following outline for investigation, were sent to the chemists desiring to take part in the work.

Instructions for phosphoric acid work for the Association of Official Agricultural Chemists for 1898.

Five samples have been prepared for use in the investigation of the methods for determining phosphoric acid for the Association of Official Agricultural Chemists for 1898.

No. 1 is the finer portion of cottonseed meal.

No. 2 is fine-ground South Carolina phosphate.

No. 3 is a chemically pure phosphate, containing about 20 per cent phosphoric anhydrid. The specimen tube contains 10 grams of the salt, accurately weighed, which should be dissolved in 1 liter of water. One hundred cc. of the solution will contain 1 gram of the phosphate.

No. 4 is fine-ground European slag meal.

No. 5 is fine-ground American slag meal.

Please determine total phosphoric acid in all five samples:

I. By the official gravimetric method (Bulletin 46, Chemical Division, United States Department of Agriculture, p. 12).

II. By the volumetric method as described at end of report.

III. Determination of available phosphoric acid by the Wagner citrate method. For this work use samples Nos. 4 and 5.

The following is a portion of the outline made by Drs. Wiley and McDonnell for the work on this subject last year, which you are requested to follow:

The Wagner citrate method.—Five grams of slag meal, without further grinding or sifting, are put into a half-liter flask and filled to the mark with dilute ammonium citrate solution, the temperature of which is 17°. The flask is closed by means of a rubber stopper, and immediately put into a revolving agitating apparatus for thirty minutes, the revolutions being made at the rate of 30 or 40 per minute. Filter at once; 50 cc of the filtrate are mixed with 100 cc of the molybdate solution and heated on the water bath at from 80° to 90° for from ten to fifteen minutes. Remove from bath and let cool to the temperature of the room and proceed in the usual way.

Wagner's concentrated ammonium citrate solution contains in 1 liter 150 grams crystallized citric acid and 23 grams of ammoniacal nitrogen. The latter is to be determined accurately by distilling the ammonia from a measured volume of the solution (after making the solution up with approximately the proper amount of ammonia to eight or nine tenths of the intended volume). The determination is made as in the Gunning method, omitting the digestion. The solution is now made up with water so that the total nitrogen per liter is 23 grams.

For use, two volumes of this solution are diluted with three volumes of water.

For further details of this method see Wiley's Agricultural Analysis, Volume II.

Results on other samples and points in the methods outlined or on subjects relating to phosphoric acid will be gladly received and credit given in the report. A plentiful supply of samples is on hand and more can be had if desired.

Please report results of your work at your convenience but in time to make up report for the association meeting.

B. W. Kilgore, *Referee.*

RESULTS BY GRAVIMETRIC AND VOLUMETRIC METHODS.

Twenty-two chemists took part in the work and the results by the two methods on the samples sent out by the referee are brought together in Table I.

TABLE I.—*Total phosphoric acid by gravimetric and volumetric methods, referee's samples.*

Analyst.	No. 1. Cottonseed meal.		No. 2. South Carolina phosphate.		No. 3. Disodium hydrogen phosphate.		No. 4. European slag.		No. 5. American slag.	
	Gravimetric method.	Volumetric method.	Gravimetric method.	Volumetric method.	Gravimetric method.	Volumetric method.	Gravimetric method.	Volumetric method.	Gravimetric method.	Volumetric method.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
W. L. Mitchell, Conn. Exp. Station.	2.92	2.97	27.88	27.91	[1]19.91	19.94	18.29	17.99	......	......
	2.92	2.99	27.88	27.91	[1]19.97	19.99	18.20	17.87	......	......
	2.87	2.99	27.94	28.00	[2]19.90	19.99	18.15	18.15	......	......
	2.97	3.03	28.03	28.00	[2]19.90	19.92	18.15	17.92	......	......
	......	......	27.93	28.00	......	......	18.27	17.95	......	......
	......	......	27.77	28.00	......	......	18.28	17.95	......	......
	......	......	27.75	......	......	......	18.08	17.95	......	......
	......	......	27.84	......	......	......	18.19	......	......	......
	......	......	......	......	......	......	18.15	......	......	......

[1] Direct precipitation with magnesia mixture.

[2] Molybdate method.

TABLE I.—*Total phosphoric acid by gravimetric and volumetric methods, etc.*—Continued.

Analyst.	No. 1. Cottonseed meal.		No. 2. South Carolina phosphate.		No. 3. Disodium hydrogen phosphate.		No. 4. European slag.		No. 5. American slag.	
	Gravimetric method.	Volumetric method.	Gravimetric method.	Volumetric method.	Gravimetric method.	Volumetric method.	Gravimetric method.	Volumetric method.	Gravimetric method.	Volumetric method.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
A. D. Cook, N. Y. Exp. Station, Geneva.	3.01	3.08	28.52	28.60	20.51	20.60	19.08	18.83	......	......
	3.01	3.10	28.50	28.60	20.54	20.50	19.06	18.73	......	......
W. H. Andrews, N. Y. Exp. Station, Geneva.	3.01	3.01	28.58	28.55	20.31	20.40	18.72	18.60	......	......
	3.01	......	28.64	28.60	20.38	20.45	18.75	18.75	......	......
	3.05	3.03	28.67	28.65	20.70	20.50	18.77	18.80	......	......
J. P. Street, N. J. Exp. Station.	3.12	3.06	28.53	28.47	19.91	19.96	18.40	18.38	......	......
	3.13	3.08	28.55	28.50	19.94	20.21	18.43	18.61	......	......
	3.17	3.12	......	......	20.01	......	18.59	18.54	......	......
	......	3.13	......	......	20.10	......	......	......	......	......
W. Skinner, Md. Agr. College.	3.11	3.11	28.04	28.02	19.84	19.80	18.26	18.52	......	......
	3.03	3.05	28.01	28.03	20.01	19.80	18.38	18.62	......	......
J. R. Laughlin, Md. Agr. College.	3.00	3.22	27.91	27.93	19.95	19.80	18.28	18.57	......	......
	3.01	3.09	28.04	28.08	19.96	19.76	18.34	18.72	......	......
C. H. Jones, Vt. Exp. Station.	3.10	2.93	28.58	28.50	20.54	20.50	18.46	18.42	18.10	17.98
	3.12	2.95	28.62	28.45	20.66	20.60	18.32	18.45	18.16	17.95
	3.01	2.98	28.46	28.55	20.54	20.60	18.42	18.50	18.00	18.00
	......	......	28.50	......	......	......	18.36	......	18.10	......
B. O. White, Vt. Exp. Station.	3.10	......	28.66	......	20.61	......	18.48	......	18.06	......
	......	......	28.52	......	......	......	18.42	......	18.00	......
	......	......	28.48	......	......	......	......	......	......	......
F. S. Shiver, S. C. Agr. College.	3.07	3.02	28.24	28.15	20.14	19.97	18.42	18.20	17.95	17.73
John Thompson, S. C. Agr. College.	3.09	3.09	28.23	28.45	20.07	20.03	18.40	18.46	17.91	17.60
C. C. McDonnell, S. C. Agr. College.	3.06	3.08	28.25	28.39	20.05	20.08	18.38	18.41	17.88	17.76
C. Glaser, Baltimore	3.02	3.02	27.98	[1] 27.76	19.89	[1] 19.88	......	......	......	......
	......	[2] 3.24	......	[2] 26.53	19.85	[2] 20.54	......	......	......	......
J. L. Stinson, Miss. Agr. College.	2.99	......	27.87	......	19.85	......	18.03	......	......	......
	3.02	......	27.85	......	19.93	......	18.00	......	......	......
	3.03	......	......	......	......	......	18.01	......	......	......
	......	......	......	......	......	......	18.11	......	......	......
W. R. Perkins, Miss. Exp. Station.	3.12	......	28.11	......	......	......	18.41	......	17.60	......
	3.17	......	28.09	......	......	......	18.43	......	17.64	......
J. S. Carroll, Miss. Agr. College.	3.11	3.09	28.02	28.00	19.88	19.90	18.43	18.27	17.88	17.77
	3.11	3.10	27.90	28.00	20.01	20.00	18.31	18.22	17.82	17.85
	......	3.06	......	28.00	......	19.92	......	18.25	17.91	17.75
	......	3.07	......	28.05	......	19.95	......	18.25	17.82	17.70
	......	3.12	......	......	......	......	......	18.20	......	......
	......	3.12	......	28.10	......	20.05	......	18.15	......	......
E. W. Magruder, Miss. Agr. College.	3.01	3.10	28.04	28.00	19.94	19.85	18.42	18.30	17.82	17.75
	2.99	3.09	28.06	27.95	19.96	19.90	18.45	18.32	17.85	17.70
	......	3.12	27.97	28.05	......	19.90	18.38	18.25	17.77	17.65
	......	3.11	28.09	27.95	......	20.00	18.54	18.25	17.76	17.68
	......	3.12	27.97	......	......	19.92	18.51	18.27	......	......
	......	......	28.08	......	......	19.95	18.55	18.30	......	......

[1] Washed with hot water.

[2] Washed with cold water.

TABLE I.—*Total phosphoric acid by gravimetric and volumetric methods, etc.*—Continued.

Analyst.	No. 1. Cottonseed meal.		No. 2. South Carolina phosphate.		No. 3. Disodium hydrogen phosphate.		No. 4. European slag.		No. 5. American slag.	
	Gravimetric method.	Volumetric method.	Gravimetric method.	Volumetric method.	Gravimetric method.	Volumetric method.	Gravimetric method.	Volumetric method.	Gravimetric method.	Volumetric method.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
E. B. Ferris, Miss. Exp.	......	3.07	28.01	28.10	19.92	19.90	18.74	18.35	18.14	17.60
Station.	......	3.07	....	28.10	19.93	....	18.68	18.25	18.19	17.60
	......	......	....	28.20	....	....	....	....	......	......
B. W. Kilgore, Miss.	3.04	3.09	27.95	28.10	19.92	19.85	[1] 18.17	18.10	17.80	17.65
Agr. College.	......	3.10	28.05	28.10	19.88	19.85	[1] 18.14	18.15	17.85	17.70
	......	......	....	....	....	19.92	[1] 18.10	18.17	17.85	17.65
	......	......	....	....	....	19.92	[2] 18.52	18.25	......	17.65
	......	......	....	....	....	19.85	[2] 18.54	18.10	......	17.65
C. C. Moore, U. S. Dept.	......	3.02	....	27.45	....	19.72	....	18.04	......	17.47
of Agr.										
E. G. Runyan, U.S. Dept.	......	......	....	....	....	....	18.12	....	17.48	......
of Agr.										
C. B. Williams, N. C.	3.02	......	27.93	....	19.89	....	18.19	....	17.27	......
Exp. Station.	3.03	......	27.95	....	19.79	....	18.09	....	17.42	......
	2.98	......	27.86	....	19.77	....	18.11	....	......	......
F. G. Kelly, N. C. Exp.	2.97	......	27.72	....	19.85	....	18.17	....	......	......
Station.	2.98	......	27.72	....	....	....	18.10	....	......	......

[1] One precipitation.

[2] Precipitated twice to get rid of iron.

Volumetric determination of phosphoric acid in referee's samples by C. C. Moore.

Sample No.	Number determinations.	Maximum.	Minimum.	Average.
		Per cent.	*Per cent.*	*Per cent.*
1	10	3.03	3.01	3.02
2	10	27.61	27.32	27.45
3	40	20.05	19.50	19.72
4	10	18.24	17.98	18.04
5	10	17.54	17.36	17.47

DISCUSSION OF RESULTS.

The results of No. 1, cottonseed meal, which contains about 3 per cent of phosphoric anhydrid, are good by both methods, with the exception of two. This is especially true, when the results of each worker by the two methods—presumably on the same solution in most cases—are compared with each other. No one has found difficulty with the volumetric method on this sample, and as this fairly represents the percentages to be determined in insoluble work in fertilizers it seems fair to assume that the method has reached the stage where it is safe and reliable for this class of work at any rate.

On sample No. 2, ground South Carolina rock, which, we think, contains about 28 per cent of phosphoric anhydrid, while the results of different analysts by the same methods vary considerably, the results of the same analyst by the two methods agree within a fairly reasonable error of analysis. Workers who have gotten high results by one method have gotten high results by the other, and vice versa. This indicates that the differences belong not to the methods themselves but to the analyst, and might reasonably be ascribed to differences in solutions, to the aliquots taken, etc.

When the high percentage of phosphoric acid in this sample is considered and the work of the past taken as a guide, the results are as good as would be expected.

The results on sample No. 3, disodium hydrogen phosphate (containing 19.83 per cent phosphoric anhydrid), compare well with each other when the results of the same analyst are considered. Quite a number of the workers have gotten high results on this sample.

Samples 4 and 6 (European and American slag meals, respectively) contain considerable iron. The volumetric results on these samples are, as a rule, lower than the gravimetric ones and, we think, more nearly represent the amount of phosphoric acid in these samples on account of the contamination of the "white precipitate" with iron from materials containing large amounts of this substance. All the "white precipitates" in my work with these samples were shown by test to contain iron, and the other workers in this laboratory found the same to be true. This is nothing new, however. The volumetric method would then seem to be a very desirable one where much iron and aluminum are present in the materials to be analyzed. It especially commends itself for use on soils, slags, etc.

Judging from the results presented, the volumetric method shows itself to be a good and reliable one. The comments of four of the twenty-two analysts taking part in the work show that they do not have it sufficiently well in hand to get thoroughly trustworthy results in all cases. The other workers have had no difficulty with it. It appears that those who have used the method sufficiently to become thoroughly familiar with its workings get good and reliable results and those who have used it most like it best.

COMMENTS OF ANALYSTS.

W. L. Mitchell, Connecticut.—The results by the volumetric method are, on the whole, very satisfactory. This good success may be attributed in part to the form of Hirsch funnel used. Those employed in past years did not contain perforations enough and were not of sufficient capacity. A more suitable form was used in this year's work. Precipitation was made at 65°, and filtration on Hirsch funnel with asbestos filter. Cold water was used for washing.

W. Skinner, Maryland.—Had difficulty in determining end reaction with Nos. 2 and 4, as the solution in the alkali became intensely blue. No. 2 is very high in aluminum, while No. 4 is high in iron. It was found difficult to wash No. 4 free from acid, which may account for high volumetric results on this sample. I also had considerable difficulty in getting concordant gravimetric results on this sample.

J. R. Laughlin, Maryland.—Also had difficulty in getting concordant results on No. 4.

C. H. Jones, Vermont.—States that he uses asbestos filter and does not have the trouble with the end reaction he formerly did when using paper. He further states that he compared the volumetric and gravimetric methods on 30 fertilizers with close agreement of results. The solutions were made in sulphuric acid. In one case, where considerable organic matter was present, the results did not agree well, but the trouble was traced to the solution, and he thinks comparative determinations on the same solutions should be made before deciding a method to be at fault.

F. S. Shiver, South Carolina.—Precipitated at room temperature and allowed to stand over night. Then filtered and washed with cold water till free of acid.

C. C. McDonnell and John Thompson, South Carolina.—Both state that they could not get uniform results with the volumetric method. The ones reported are the averages of results showing closest agreement.

C. Glaser, Baltimore, Md.—Used warm water (80° to 90°) for washing, and found it worked better than cold water. He washed with about 300 cc.

C. C. Moore, United States Department of Agriculture.—States: I can detect no difference in the two methods of washing and found no advantage in the use of nitric acid. I generally use the perforated platinum cone with filter paper with slight suction. The washing is continued until the funnel three times filled does not neutralize one-half drop of the standard alkali.

The alkaline solution was standardized by actual determinations of the chemically pure salt, No. 3. Ten determinations, using from 0.01 to 0.12 gram of the salt, were made. The end reactions were very uniform. There was but slight variation, and the maximum and minimum samples gave identical results.

J. S. Carroll, Mississippi.—It was found necessary to precipitate twice with molybdic solution to get rid of iron in samples 4 and 5. The "white precipitates" were then not entirely free from it.

Filtration through an asbestos filter on a perforated disk in a Gooch crucible tube was found to be the most satisfactory way. The glazed porcelain Gooch crucible with false bottom covered with an asbestos filter also works well.

TEST OF METHODS OF PRECIPITATION WITH VOLUMETRIC METHOD.

Considerable time was given in the laboratory of the Mississippi Agricultural College to testing methods of precipitation, the quantity of molybdic solution best to use in the volumetric method, etc. These investigations were made on the cottonseed meal, disodium hydrogen phosphate, and European slag samples sent out by the referee. The work was done by Messrs. E. W. Magruder, J. S. Carroll, and the referee. The results are presented in Table II, which follows:

TABLE II.—*Test of methods of precipitation when using the volumetric method.*

COTTONSEED MEAL.

Sample.	Gravimetric results by usual method.	Volumetric results.	Time allowed for precipitation.	Temperature of precipitation.	Amount of substance used.	Amount molybdic solution used.
	Per cent.	*Per cent.*	*Hours.*	°*C.*	*Grams.*	*cc.*
No. 1	3.10	3.04, 3.04, 3.03, 3.05	½	65	0.4	15
		3.05, 3.05	½	65	.4	20
		3.12, 3.16, 3.17, 3.09, 3.10, 3.17, 3.07.	½	65	.4	30
		2.98, 3.00, 2.98, 2.91, 2.75	1	30	.4	15
		2.93, 3.08, 3.03, 3.06	1	30	.4	30
		3.04, 3.04, 3.03, 3.02, 3.05, 3.04	7	31-27	.4	20
No. 1 *a*	.52	0.54, 0.55, 0.54, 0.54, 0.54, 0.53	17	31-27	.4	20
No. 1 *b*	.26	0.27, 0.26, 0.27, 0.27, 0.26, 0.26	17	31-27	.4	20
Reverse precipitation		3.07, 2.91, 2.90	1	30	.4	15
		3.10, 3.10, 3.07	1	30	.4	30

DISODIUM HYDROGEN PHOSPHATE.

Sample.	Gravimetric results by usual method.	Volumetric results.	Time allowed for precipitation.	Temperature of precipitation.	Amount of substance used.	Amount molybdic solution used.
No. 3	19.95	19.85, 19.90, 19.90, 19.85, 19.85.	½	65	0.2	30
		20.00, 20.00, 19.95, 19.97, 19.92, 19 95, 19.90, 19.92, 20.05, 19.97.	½	65	.2	35
		20.10, 20.25, 20.20, 20.20, 20.18, 20.15, 20.22, 20.20.	½	65	.2	50
		19.84, 19.90, 20.00, 20.00, 19.50, 19.10.	½	65	.1	15
		20.23, 20.30, 20.25	½	65	.1	80
		20.20, 20.15, 20.40	¾	65	.1	30

TABLE II.—*Test of methods of precipitation when using the volumetric method*—Continued.

DISODIUM HYDROGEN PHOSPHATE—Continued.

Sample.	Gravimetric results by usual method.	Volumetric results.	Time allowed for precipitation.	Temperature of precipitation.	Amount of substance used.	Amount molybdic solution used.
	Per cent.	*Per cent.*	*Hours.*	°*C.*	*Grams.*	*cc*
		19.65, 19.42, 19.62	¾	31	.2	30
		19.95, 19.95, 20.00	¾	31	.2	50
		19.95, 19.95, 19.95	1	28	.2	35
		19.95, 19.90, 19.90	1	31	.2	40
		19.40, 19.30, 19.00, 19.90, 19.68, 19.50.	1	20	.2	32
		19.88, 19.85, 19.85	15.5	24-25	.2	32
		19.90, 19.89, 19.90	15.5	24-25	.2	55
Reverse precipitation		19.20, 19.30	½	20	.2	32
		19.95, 19.90, 19.90	1	20	.2	32
		19.95, 19.95, 19.98	1	28	.2	35
		19.95, 19.98, 19.95	1	31	.2	40
		20.05, 19.95, 19.90, 19.88, 19.83, 19.83.	½	30	.2	30
		20.05, 20.02, 19.98, 20.05, 19.98, 19.98.	½	30	.2	50

EUROPEAN THOMAS SLAG.

No. 4 (regular precipitation).	18.47	18.20, 18.23, 18.23	17	24-25	0.2	32
		18.25, 18 27, 18.27	17	24-25	.2	35
		18.33, 18.32, 18.25, 18.27	½	65	.2	40

From the results presented and observations made in the course of the work we feel warranted in drawing the following conclusions:

That at a temperature of 65° 10 cc of molybdic solution did not always precipitate the phosphoric acid in the cottonseed meal, containing about 3 per cent, in one-half hour, but 15 cc did, and as much as 25 cc of the molybdic solution could be added without giving high results. Thirty cc gave slightly but not very materially higher results than from 15 to 25 cc of molybdic solution. When precipitation was made at room temperature in the summer it could not be relied upon to be complete in one hour, but on standing over night this 3 per cent sample and ones containing 0.50 per cent and 0.25 per cent were complete in all cases. Large excess of molybdic solution did not give high results on these percentages when precipitation was made in the cold. An aliquot corresponding to 0.4 gram substance was used on these percentages.

For samples 3 and 4, containing 18 and 20 per cent phosphoric anhydrid, 30 cc of molybdic solution gave complete precipitation at 65°, and 35 and 40 cc could be used without increasing the results, but 50 and 55 cc of solution gave high results, showing that a large excess of molybdic solution in the volumetric method will give high results when precipitation is made at 65°. One hour in the cold with the above amounts of molybdic solution did not always give complete precipitation, but on standing over night (from fifteen to seventeen hours) all the phosphoric acid came down, and a large excess of molybdic solution (45 to 55 cc) did not give as high results as when precipitation was made at 65°. Precipitation in the cold took place quicker with these high percentages than with the low ones.

REVERSE PRECIPITATION.

The addition of the phosphate solution to the molybdic solution containing the necessary ammonium nitrate brought down the ammonium phosphomolybdate somewhat quicker than the usual procedure, but the difference did not seem to be very great.

PRECIPITATION BY SHAKING IN THE COLD.

The following tests were carried out to see if shaking at room temperature would give complete precipitation. The machine used was the revolving one commonly employed in determining the available phosphoric acid in slags by the Wagner citrate method. Shaking was continued for from fifteen to sixty minutes, the machine being run by a small gas engine at the rate of about sixty revolutions per minute.

The results show precipitation to have been complete in all these 73 determinations, though the time of shaking was only fifteen minutes in a number of the tests and filtration was carried out at once. A small excess of molybdic solution brought down all the phosphoric acid in this work, and the use of a double quantity did not increase the results as it did when precipitation was made at the usual temperature, 65°.

It appears on the basis of these results that this means of precipitation by shaking at room temperature in some convenient form of machine is a most promising one for giving quick and complete precipitation, and the conditions in it are not favorable for the precipitation of molybdic acid along with the ammonium phosphomolybdate. It is recommended for further study.

TABLE III.—*Test of shaking as a means of precipitation of phosphoric acid in the volumetric method.*

[E. W. Magruder, analyst, Mississippi Agricultural College.]

Sample.	Gravimetric results by usual method.	Volumetric results by shaking.	Time of shaking.	Temperature of precipitation	Amount of substance used.	Amount of molybdic solution used.
	Per cent.	*Per cent.*	*Minutes.*	°*C.*	*Grams.*	*cc.*
		COTTONSEED MEAL.				
No. 1	3.10	3.00, 3.03, 3.03	60	31	0.4	20
		3.06, 3.03, 3.03	30	31	.4	20
No. 1*a*	.52	0.55, 0.55, 0.55, 0.55, 0.53	30	25	.4	15
		0.55, 0.56, 0.55, 0.55, 0.56, 0.55	30	25	.4	30
No. 1*b*	.26	0.31, 0.30, 0.30, 0.27, 0.27, 0.28	30	27	.4	15
		0.26, 0.26, 0.27, 0.26, 0.27, 0.27	30	27	.4	30
		PHOSPHATE ROCK.				
No. 2	28.04	28.03, 28.05	30	24	0.1	25
		28.05, 28.08	30	24	.1	50
		DISODIUM HYDROGEN PHOSPHATE.				
No. 3	19.95	20.00, 19.98, 20.00	30	27	0.2	40
		19.92, 19.95	40	30	.2	32
		19.95, 19.90, 19.88	20	28	.2	32
		19.90, 19.75, 19.85	20	28	.2	55
		19.95, 19.95, 19.92	15	28	.2	32
		19.92, 19.90, 19.90	15	28	.2	55

TABLE III.—*Test of shaking as a means of precipitation of phosphoric acid in the volumetric method*—Continued.

Sample.	Gravimetric results by usual method.	Volumetric results by shaking.	Time of shaking.	Temperature of precipitation.	Amount of substance used.	Amount of molybdic solution used.
EUROPEAN SLAG.						
	Per cent.	*Per cent.*	*Minutes.*	°C.	*Grams.*	*cc.*
No. 4	18.47	18.25, 18.20, 18.20, 18.25, 18.20, 18.25, 18.25.	30	25	0.2	30
		18.20, 18.20, 18.25, 18.20, 18.30	30	25	.2	50
AMERICAN SLAG.						
No. 6	17.80	17.65, 17.65, 17.65, 17.60, 17.67	30	24	0.2	30
		17.73, 17.70, 17.70	30	24	.2	50
FERTILIZERS.						
Total	12.66	12.58	30	....	0.2	30
Soluble	9.00	8.97	30	....	.2	25
Insoluble	2.08	2.10	30	....	.4	20

RESULTS FROM MISCELLANEOUS FERTILIZER SAMPLES BY GRAVIMETRIC AND VOLUMETRIC METHODS.

Mr. F. S. Shiver, of the South Carolina Agricultural College, compared the gravimetric and volumetric methods on totals, solubles, and insolubles in a number of fertilizers. He precipitated at room temperature, allowed to stand over night, and washed with cold water.

Mr. E. W. Magruder also made a number of comparative tests in the course of regular work. Precipitation was made at 65° C. and allowed to stand fifteen minutes. The washing was done with cold water. Results are presented in Table IV.

TABLE IV.—*Results from miscellaneous fertilizers by gravimetric and volumetric methods.*

[F. S. Shiver, analyst, South Carolina Agricultural College.]

TOTALS.

Sample No.	Gravimetric method.	Volumetric method.	Sample No.	Gravimetric method.	Volumetric method.
	Per cent.	*Per cent.*		*Per cent.*	*Per cent.*
1	15.91	15.92	6	2.62	2.62
2	15.68	15.79			2.54
3	10.06	10.17	7	30.16	30.25
4	27.96	28.13	8	42.35	42.10
		28.18	9	15.91	15.96
		28.18			16.09
5	22.60	22.58	Average	20.36	20.40
		22.58			

TABLE IV.—*Results from miscellaneous fertilizers by gravimetric and volumetric methods*—Continued.

SOLUBLES.

Sample No.	Gravimetric method.	Volumetric method.	Sample No.	Gravimetric method.	Volumetric method.
	Per cent.	*Per cent.*		*Per cent.*	*Per cent.*
1	10.44	10.59	5	6.54	6.54
2	6.58	6.65			6.56
3	6.98	7.06	6	9.93	9.98
4	8.88	8.91	Average	8.23	8.29
		8.93			

INSOLUBLES.

1	1.32	1.24	8	1.09	1.07
2	1.27	1.11	9	1.47	1.46
3	1.50	1.46	10	1.34	1.38
4	1.36	1.32	11	1.23	1.23
5	1.83	1.77	12	1.28	1.29
6	1.62	1.72	Average	1.54	1.51
7	3.11	3.10			

[E. W. Magruder, analyst, Mississippi Agricultural College.]

INSOLUBLES.

869	0.90	0.97	876	1.45	1.49
		.96			1.47
		1.00			1.47
870	.90	.95	877	1.11	1.15
		.96			1.14
		.96			1.02
871	.88	.97	880	2.55	2.57
		.95			2.52
		.95			2.54
872	1.20	1.24	882	1.25	1.31
		1.24			1.31
873	3.71	3.65			1.30
		3.74	856	2.39	2.42
874	2.64	2.60			2.37
		2.62			2.41
		2.65			2.40
875	1.87	1.82			
		1.82			
		1.85			

TOTALS.

850	9.74	9.82
		9.88

PRECIPITATION AND WASHING.

Precipitation.—Two methods of precipitation were outlined in the instructions for the work the past season. One was to heat to about 65° and the other to about 50° before adding the molybdic solution. Most of the analysts precipitated at 65°, and at least three worked at room temperature and allowed to stand over night, when precipitation was completed in all cases.

Washing.—Nearly all of the analysts washed with water only. A large number of tests in one laboratory showed the decantation washing with dilute nitric acid to have no advantage. Washing once or twice by decantation with water, and then on the filter with enough water to make with the decantation washings about 200 cc, was found sufficient to free the precipitate of acid. In this laboratory we have not found it necessary to test the filtrate for acid after washing in this way, but proceed at once with the titration, a large number of tests having shown us that all acid has been removed. The precipitate may be washed with 300 cc, and in some cases as much as 400 or 500 cc of water without material loss, but it is to be remembered that ammonium phosphomolybdate is an acid salt which is slightly soluble in water, enough so to make the filtrate react acid to delicate indicators. Besides the danger of dissolving a small amount of the salt when very large amounts of water are used, some of the precipitate is liable to run through the filter when as much as 500 or 600 cc of water are used for washing.

FILTERS.

A number of forms of filters have been used with the volumetric method. Among these we would name in the order of preference: (1) That made by putting a perforated porcelain or other disk well filled with holes in the glass carbon filters used for Gooch crucibles, attaching a stiff piece of wire to the plate with which to push it out of the tube, and covering the plate with an asbestos filter. (2) The porcelain Gooch crucible, of good size, with false bottom well filled with holes, the bottom being covered with an asbestos filter. (3) The Hirsch funnel, with bottom well filled with holes and covered with an asbestos filter. (4) Funnel and filter paper with or without pressure.

STANDARD SOLUTION AND INDICATOR.

As the titration is to be made with phenolphthalein as indicator the solutions should be standardized with this indicator. We use alcohol distilled over sodium or potassium hydroxid (free from carbonates) for making the standard alkali. For each liter of solution dissolve the alkali in 120 to 130 cc of alcohol, filter from insoluble carbonates, and dilute with water. Much more alcohol than this should not be used, as it might give reduction and consequent coloration in the titration.

CARBON DIOXID IN DISTILLED WATER.

Distilled water obtained from water containing large amounts of bicarbonates is liable to have considerable carbon dioxid in solution. There is no objection to the use of this water for washing the yellow precipitate, but in transferring the precipitate to the beaker or precipitating vessel and diluting in the process of titration a small error may be introduced. Boiling the water used for this purpose obviates any difficulty from that source.

RECOMMENDATIONS.

(1) That precipitation at room temperature in the volumetric method by means of shaking in some convenient form of shaking machine be made a subject of study.

(2) That the volumetric method for the estimation of phosphoric acid by titrating the ammonium phosphomolybdate precipitate with standard alkali be made an optional method.

DESCRIPTION OF VOLUMETRIC METHOD.

Dissolve substance according to methods (A2), (A5), (A6), or (A7) (Bulletin 46, Division of Chemistry, United States Department of Agriculture, p. 12), preferably by (A5) when these acids are a suitable solvent, and dilute to 200 cc with water. For percentages below 5, measure out aliquot corresponding to 0.4 gram substance, for percentages between 5 and 20 use aliquot corresponding to 0.2 gram substance, and for percentages above 20 use aliquot corresponding to 0.1 gram substance. Add 5 to 10 cc nitric acid (or the equivalent in ammonium nitrate), depending on the method of solution, nearly neutralize with ammonia, dilute to from 75 to 100 cc, heat in water bath to from 60 to 65°, and for percentages below 5 add from 20 to 25 cc freshly filtered molybdic solution (official), for percentages between 5 and 20 add from 30 to 35 cc solution, and for percentages above about 20 add from 3) to 35 cc molybdic solution. Stir, let stand about fifteen minutes, filter *at once*, wash once or twice by decantation with water, using from 25 to 30 cc each time, agitating the precipitate thoroughly and allowing to settle, transfer to filter and wash five or six times, using enough water to make with the decantation washings about 200 cc. Transfer precipitate and filter to beaker or precipitating vessel, dissolve in small excess of standard alkali, add a few drops of phenolphthalein solution and titrate back with standard acid (nitric).

PREPARATION OF REAGENTS.

(*a*) *Standard potassium hydroxid solution.*—This solution contains 18.17106 grams of potassium hydroxid to the liter. It is prepared by diluting to 1 liter 323.81 cc of normal potassium hydroxid, which has been freed from carbonates. One hundred cc of the solution should neutralize 32.38 cc normal acid. One cc is equal to one mg P_2O_5 (1 per cent P_2O_5 on basis of 0.1 gram substance).

(*b*) *Standard nitric acid solution.*—The strength of this solution is the same as, or one-half that of, the standard alkali solution, and is determined by titrating against that solution, using phenolphthalein as indicator.

(*c*) *Phenolphthalein solution.*—One gram of the phenolphthalein is dissolved in 100 cc of alcohol.

In addition to the method as adopted the following suggestions are offered by the referee:

Filters in the following order of preference are recommended: (1) That made by putting a perforated porcelain or other disk, well filled with holes, in the glass carbon filters used for a gooch, attaching a stiff piece of wire to the plate with which to push it out of the tube, and covering the plate with an asbestos filter. (2) The porcelain gooch of good size with false bottom well filled with holes, the bottom being covered with an asbestos filter. (3) The Hirsch funnel with bottom well filled with holes and covered with an asbestos filter. (4) Funnel and filter paper with or without pressure.

Instead of precipitating at 65° C, precipitation may be made at room temperature by shaking for about thirty minutes in some convenient form of shaking machine.

The president called for papers on phosphoric acid and discussion of the report of the referee.

In regard to the estimation of available phosphoric acid in basic slag, Mr. Wheeler stated that he had attended the meeting of the representatives of the German experiment stations last summer, and that in view of the fact that much difficulty has been experienced in the past in obtaining comparative results even on the same sample in different German laboratories, Professor Wagner proposed that a 2 per cent citric acid solution be adopted in lieu of the acid citrate solution previously employed, and that the conditions of treatment should remain the same as heretofore. His suggestion was very strongly supported by Professor Maercker, of Halle, and a few others. The result is that members of the association are to make a trial of the method, and they are to meet, probably in January, in Berlin, in order to consider its final adoption. It is supposed to give about 1 per cent more of available phosphoric acid in ordinary slags than the usual citrate method. but it is hoped that it will accord very closely with the results obtained in vegetation experiments, and such further experiments will be conducted in order to ascertain if it be more reliable as a guide to the assimilability than the method formerly employed.

At the conclusion of the discussion, the committee appointed to wait upon the Secretary and Assistant Secretary of Agriculture announced that it had performed the duties imposed upon it. The Secretary of Agriculture received the committee and promised to attend the convention at some period of its sessions, but was unable to name a definite hour. The Assistant Secretary was absent from the city and therefore could not be seen.

The president called for the reports of the committee on recommendations of referees. The committee made the following report upon the recommendation of the referee on nitrogen:

> The committee upon recommendations of referees recommends the adoption of the recommendation of the referee on nitrogen that a further trial be made of the potassium permanganate methods for the determination of the availability of organic nitrogen in fertilizers.

The report of the committee was adopted.

The committee also presented the following report on the recommendations of the referee on potash:

> Your committee concurs with the referee in the recommendation that the Lindo-Gladding method be adopted for determining water soluble potash in wood ashes and cotton-hull ashes, special attention being paid to the words "The precipitate should be perfectly soluble in water," found in the description of this method on page 2, Circular No. 4, United States Department of Agriculture, Division of Chemistry.

The report of the committee was approved.

The committee also presented the following report on the recommendations of the referee on phosphoric acid:

> Your committee recommends that the volumetric method for the determination of phosphoric acid as described in the report of the referee be adopted as an optional method.

After a somewhat prolonged discussion the action of the committee was approved.

At 4 o'clock the association adjourned until Saturday morning.

SECOND DAY.

SATURDAY—MORNING SESSION.

After the dispatch of some routine business, and announcements by the secretary and others, the president called for the report of the referee on soils and ash. The report was read by the referee, Mr. Harry Snyder.

REPORT ON SOILS AND ASH.

By HARRY SNYDER, *Referee.*

The referees on soils and ash were instructed by this association to continue the investigations relating to the use of a fifth normal hydrochloric acid solution as a solvent for the available phosphoric acid of the soil, and the calcium chlorid and the ammonium chlorid methods for the determination of available potash.

It was also considered advisable to include the determination of (1) the total nitrogen, (2) the nitrogen content of the humus, and (3) the calcium in the form of calcium carbonate. A circular letter was issued inviting the cooperation of all station chemists. Fourteen favorable replies were received, and reports were obtained from six laboratories.

It was thought best to secure results from as large a number of soils as possible, so that the accuracy of the methods might be tested on different types of soil. Ten soils were selected for the work. Some difficulty was experienced in securing suitable samples. While it is claimed that $60,000,000 worth of commercial fertilizers are annually used in this country, it is surprising to find how small a number of soils are known from carefully conducted experiments to be deficient in one or more of the essential elements of plant food.

DESCRIPTION OF SOILS.

Soil No. 1. Deficient in available phosphoric acid.—This soil was secured by Mr. A. M. Peter, of the Kentucky Station, from the farm of Mr. Thomas R. Walker at Junction City, Ky. Experiments have shown that this soil is deficient in available P_2O_5, and is apparently well supplied with available potash, although there is no superabundance of that element. (Ky. Bulletin 61, pp. 11–14). This land had a few months previously received a dressing of 200 pounds per acre of acid phosphate.

Soil No. 2. Deficient in available potash.—From the Kentucky Agricultural Experiment Station. This soil has never received any fertilizer, and experiments conducted for a series of years indicate poverty in K_2O.

Soil No. 3. Deficient in available nitrogen.—From near Raleigh, N. C., furnished by Mr. Withers, of the North Carolina Experiment Station. This soil is deficient to a less extent in available P_2O_5.

Soil No. 4. Deficient in available nitrogen.—From the North Louisiana Experiment Station, furnished by Director Stubbs. This soil is also slightly deficient in available phosphoric acid, and while analyses have shown it to be deficient in potash we fail to see any response to any form of this ingredient. This soil has never been fertilized.

Soil No. 5. Mixed soils.—From the Ohio Experiment Station. This soil is now under investigation, and Director Thorne states that he is not yet prepared to say just what constituents are lacking. This sample was made up from twenty-seven separate samples taken from nine plots. Inasmuch as this soil is to be subjected to careful field tests with fertilizers, it will be interesting to observe to what extent the laboratory results agree with the field tests.

Soil No. 6. "Worn-out soil."—From near Columbia, Mo. Director Waters writes that this soil has been cropped without manures for over forty years, and it has been so reduced in crop-producing power that it yields less than 5 bushels of corn per acre, while adjoining land, as soil 6A, which has been properly manured, yields 60 bushels per acre.

Soil No. 7. Deficient in lime.—From the Rhode Island Experiment Station.

Soil No. 8. Virgin soil of average fertility.—From the Minnesota Experiment Station. Similar soils which have been cropped for thirty years show no material response when commercial fertilizers are applied, but are benefited by applications of stable manure.

Soil No. 9. Virgin soil of high fertility.—From the substation at Crookston, Minn. Similar soils which have been cropped for ten years are not benefited by applications of commercial fertilizers, but, if anything, show a slight decline in yields when they are used.

Soil No. 10.—For mechanical analysis.

DIRECTIONS FOR WORK ON A. O. A. C. SOIL SAMPLES FOR 1898.

(1) The Determination of Moisture.

Use the official method described in Bulletin 46, page 38, Division of Chemistry, United States Department of Agriculture. Calculate all results to the water-free basis.

(2) The Determination of Phosphoric Acid Soluble in N/5 HCl.

(*a*) *Preliminary treatment.*—Digest 20 grams of soil with 200 cc of N/5 HCl in a water bath at 40° for five hours. Titrate 20 cc of the clear filtrate against a standard KOH solution, using phenolphthalein for the indicator. From the data thus secured calculate the amount of HCl necessary to be added so that the solution will be N/5 after allowing for the acid neutralized.

(*b*) *The determination.*—Place from 50 to 100 grams of soil in an Erlenmeyer flask, and add 10 cc of acid corrected for neutralization, as directed under (*a*), for every gram of soil used. The flask is corked with a rubber stopper which carries a thermometer. The flask is placed in a water bath previously heated to 40°. The soil is digested for five hours at a temperature of 40°, and the contents of the flask are thoroughly shaken every half hour during the digestion.

The solution is filtered through a ribbed filter of two thicknesses of paper, refiltering the first portion if cloudy. The filter should be large enough to receive the entire contents of the flask. Before filtering the contents of the flask are well shaken. From 400 to 600 cc of the filtrate (at 20°) are evaporated to dryness after adding from 1 to 3 cc HNO_3. If there be any appreciable amount of organic matter present, the residue is to be carefully ignited. Moisten the residue with HCl and add from 50 to 100 cc distilled water and digest. Filter, neutralize with ammonia, add 5 cc strong HNO_3 and 15 grams of ammonium nitrate in solution. Complete the determination according to one of the official methods given for the determination of phosphoric acid, or use the Goss method, as given in Circular 4 to accompany Bulletin No. 46.

(3) The Determination of Potash Soluble in N/5 $CaCl_2$.

Prepare a N/5 solution of $CaCl_2$ by dissolving the chemically pure salt in distilled water and titrating against standard $AgNO_3$, using potassium chromate as an indicator.

Digest 30 grams of soil with 500 cc of this solvent for five hours at 40°, as directed in section 2. Evaporate 400 cc of the filtrate to dryness in a porcelain dish after adding a few cc of HCl and HNO_3. Take up with water, add ammonium hydrate to alkaline reaction, and precipitate lime, etc., with ammonium carbonate and oxalate. Filter, add ½ cc of concentrated H_2SO_4 to the filtrate and evaporate to dryness in a large platinum dish. Thoroughly dry in the air bath at from 140° to 150°, ignite, and continue the determination by the Lindo-Gladding method.

(4) THE DETERMINATION OF POTASH SOLUBLE IN AMMONIUM CHLORID.

Make up a N/20 solution of ammonium hydrate by titrating against standard acid, using cochineal as the indicator, and dissolve 10.68 grams of chemically pure crystalline NH_4Cl in each liter of the same.

Digest 50 grams of soil with 500 cc of this solvent exactly as under 2. Evaporate 400 cc of the filtrate to a small volume in a porcelain dish, transfer to a good-sized platinum dish, add ½ cc of concentrated H_2SO_4, and finish the evaporation over a water bath. Heat in the air bath at from 140° to 150°, ignite, and continue the determination by the Lindo-Gladding method.

(5) THE DETERMINATION OF TOTAL NITROGEN.

Use the method outlined on page 2 of Circular No. 2 accompanying Bulletin No. 46. Nitrates are not to be included.

(6) THE NITROGEN CONTENT OF THE HUMUS.

Place from 10 to 25 grams of soil in a 200 cc glass-stoppered bottle. Add 150 cc of a 1 per cent solution of HCl; if the soil contain a higher per cent of lime use a 2 per cent HCl solution. Allow the acid to act on the soil for about five hours, with occasional shaking of the contents of the flask. Decant into a filter, add a fresh quantity of acid to the soil, decanting at the end of two hours. Continue to treat the soil with acid until no reaction for calcium is obtained; then wash with distilled water until the washings are only slightly turbid to $AgNO_3$. The soil on the filter is then transferred to the glass-stoppered bottle, using 150 cc of a 3 per cent NaOH solution. The bottle is occasionally shaken, and after from three to five hours the solution, after settling, is decanted into a 500 cc flask. A fresh quantity of alkali is added, and the treatment is continued until the extract becomes nearly colorless. Three or four treatments are usually necessary. The solution in the flask is made up to 500 cc, shaken well, allowed to settle, and then a 200 to 400 cc filtered portion is placed in a Kjeldahl digestion flask, neutralized with H_2SO_4 and evaporated nearly to dryness. The nitrogen determination is completed in the usual way.

(7) THE DETERMINATION OF CALCIUM CARBONATE.

(*a*) To 100 grams of soil in a large flask or bottle add 2,500 cc of water saturated with pure CO_2 (made from Na_2CO_3 or $NaHCO_3$). Shake the flask twice a day and allow the solution to act on the soil for three days. To 2,000 cc of the clear filtrate add HCl until acid and evaporate to dryness. In the presence of organic matter the residue is carefully ignited and then dissolved in 50 cc distilled water and 2 cc HCl. Ammonia is added; any precipitate obtained is removed by filtering. Ammonium chlorid is added and the calcium is then precipitated with ammonium oxalate. The calcium is determined volumetrically, with a N/10 permanganate solution. Report results as CaO.

(8) DETERMINATION OF COARSE AND MEDIUM SAND.

Place 10 grams of soil in a small beaker; add about 100 cc of water and heat for ten minutes on a sand bath. During the heating pestle the soil with rubber-tipped glass rod. Connect the 0.5 mm sieve by means of a Gooch crucible fitting with a filtering flask. Pour the contents of the beaker into the sieve, using the glass rod if necessary to prevent clogging. Wash the material in the sieve with distilled water until the washings are clear, then pass 100 cc more water through the sieve. Remove the sieve to a drying oven, and when dry transfer the contents to a crucible. Ignite, and weigh.

The contents of the flask are then passed through the 0.25 mm sieve, and the particles between 0.5 and 0.25 mm determined.

Determine the moisture in a separate sample of soil, and report all results on dry soil.

The results obtained by different analysts in respect of phosphoric acid are found in the following table:

Soil No.	Description.	Total P_2O_5.	Solution HCl.	Per cent phosphoric acid soluble in N/5 HCl.									
				New Mexico.		South Carolina, Thompson.	Minnesota, Snyder.	Canada.		Rhode Island, Hartwell.	Massachusetts, Haskins.	Department of Agriculture, Moore.	Average.
				Goss.	Holt.			Shutt.	Charran.				
		Per cent											
1	Deficient in P_2O_5......	0.05	N/4.99	0.002	0.004	0.002	0.003	0.004	0.004	0.0025	0.0013	0.002	0.0026
4	Deficient in P_2O_5	....	N/4.99	.....	.....	.....	.002	.0026	.....	......	......	.....	.0023
5	Deficiency unknown..	.10	N/4.99	.....	.....	.....	.003	......	.....	......	.0024	.003	.0028
6	General poverty	.05	N/4.49	.002	.003	.002	.002	......	.....	......	......	.....	.0022
8	Virgin soil, average fertility.............	.17	N/4.74	.022	.019	.033	.032	......	.019	.0170	.0300	.038	.0260
9	Virgin soil, high fertility	.23	N/2.60	.063	.065	.061	.061	.035	.028	......	.0670	.058	.0550

The HCl solution was N/5 after correcting for basic material in the soils

Soil No. 9 digested in N/5 HCl without correcting for basic material gave 0.044 per cent P_2O_5.

The phosphoric acid results are as a whole satisfactory. Soil No. 1, known to be deficient in available P_2O_5, shows an average of 0.0029 per cent soluble in fifth normal hydrochloric acid, or less than 100 pounds per acre. Similar results were obtained from soil No. 4, which is deficient in P_2O_5. In soil No. 6, the one of general poverty, there is only 0.0022 per cent soluble P_2O_5. Soil No. 5, according to the analytical results, is deficient in available P_2O_5. A recent bulletin from the Ohio Experiment Station states that field experiments "apparently justified the conclusion that, for the soils and crops under test, phosphoric acid is at present the most important constituent of a fertilizer, with nitrogen and potash following in the order named." In the case of this soil the laboratory results anticipated the field results. With soils Nos. 8 and 9, known to contain liberal amounts of phosphoric acid, the results show respectively ten and twenty times as much soluble phosphoric acid as in the case of soils deficient in this element.

The presence of two-thousandths of a per cent of an element in a soil report may seem to many like a very small amount, and to be within the limits of error in ordinary analytical work. The percentage amounts are small because such a large amount of soil is used, and not because there is only a small weighable amount of material. In fact, nearly 40 mg of magnesium pyrophosphate are secured for final weighing. In water analysis the figures for albuminoid ammonia would be even less than 0.002 per cent calculated on a percentage basis.

The citric acid method, as proposed by Dyer, has also been subjected to further investigation, with the following results:

Analyst.	Soil No. 1. Deficient in available P_2O_5.	Soil No. 4. Deficient in available P_2O_5.	Soil No. 8. Virgin soil, not deficient. Average fertility. P_2O_5.	Soil No. 9. Virgin soil, not deficient. High fertility. P_2O_5.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Shutt, Canada	0.0054	0.0026	0.0197	0.0189
Charran, Canada	.0054			.0196
Hummel, Minnesota	.0048		.0210	.0175

While the results by citric acid show a difference between soils deficient and soils well stocked with available phosphoric acid, the method does not make as sharp a distinction as the N/5 HCl method. In fact, citric acid shows but little difference between the amounts of soluble phosphoric acid in soils 8 and 9, while the N/5 HCl shows a marked difference. Soil No. 9 is much more liberally supplied with available phosphoric acid. In former reports it has been shown that 1 per cent citric acid fails to give satisfactory results for the determination of the available P_2O_5 of the soil. (Goss, p. 87, Association Report, 1896.)

Some objection has been made against the use of N/5 HCl as a solvent for available phosphoric acid on the ground that it is too active a solvent. In the case of soil No. 1, deficient in available P_2O_5, citric acid was a more active solvent than N/5 HCl, while in the case of soil No. 9, which contains a liberal supply, the N/5 HCl was the more active solvent. This difference, however, is in favor of the HCl. How this would hold in the case of a large number of soils of course can not be told.

POTASH.

[Soluble in N/5 $CaCl_2$.]

Analyst.	Soil No. 2. Deficient in available K_2O.	Soil No. 8. Virgin soil. Average fertility. K_2O.	Soil No. 9. Virgin soil. High fertility. K_2O.
	Per cent.	*Per cent.*	*Per cent.*
C. C. Moore, U. S. Dept. Agr	0.0090	0.0170	0.0270
F. S. Shiver, South Carolina	.0030	.0106	
Jno. Thompson, South Carolina	.0027	.0095	.0295
B. L. Hartwell, Rhode Island	.0080	.0136	
Harry Snyder, Minnesota	.0070	.0156	

[Soluble in alkaline NH_4Cl.]

C. C. Moore, U. S. Dept. Agr	0.0090		
F. S. Shiver, South Carolina	.0067		
Jno. Thompson, South Carolina	.0071		
B. L. Hartwell, Rhode Island	.0148		
Harry Snyder, Minnesota[1]	.0142	0.02	0.077

[1] Huston reports on this same soil 0.0137. Bulletin No. 49, U. S. Dept. Agr.

Potash results from Minnesota Experiment Station Laboratory by the referee.

	Per cent.
Soil No. 1.—Fair amount of available K_2O	0.0092 .0089
Soil No. 2.—Deficient in available K_2O	.013 .0154
Soil No. 5.—Fair amount of available K_2O	.0123 .0119
Soil No. 6.—General poverty	.019 .023
Soil No. 8.—Virgin soil, average fertility	.02
Soil No. 9.—Virgin soil, high fertility	.077

In the above determinations the double salt of potassium and platinum was obtained in the usual way and was then dissolved in distilled water acidified, and the platinum determined by electrolysis. By means of electrolysis it is possible to make potassium determinations and avoid the foreign materials usually present in the final product.

In soil analysis it is quite essential that the impurities be removed, because they are present in larger amounts than in ordinary fertilizer work. The electrolytic method for the determination of potash is particularly applicable to soil work where abnormal amounts of impurities are present. The cause of the unusual discrepancies in the results on soil potash in former years has undoubtedly been due to the variable amounts of impurities present in the final product.

Soluble in 1 per cent citric acid.

[Results reported by Mr. Shutt, chemist, Dominion Experiment Farms.]

	Soil No. 1. Fair amount of available K_2O.	Soil No. 4. Fair amount of available K_2O.	Soil No. 8. Virgin soil, average.	Soil No. 9. Virgin soil, high.
K_2O solution, soluble in 1 per cent citric acid solution	*Per cent.* 0.0129	*Per cent.* 0.0126	*Per cent.* 0.0111	*Per cent.* 0.0204

In the case of the ammonium chlorid method for the determination of available potash, it is to be observed that a higher per cent of soluble potash was obtained from soil No. 1, deficient in available potash, than from No. 2, which contains a fair amount, and that soil No. 6, general poverty, shows more soluble potash than No. 8, a virgin soil of average fertility. The method gives valuable indications where the soils most deficient in potash are compared with those which are most liberally supplied with potash, as No. 9.

Citric acid gives but little promise as a solvent for available potash. The virgin soil of average fertility contains less potash soluble in citric acid than soil No. 1, which is deficient in available potash.

Sufficient results were not secured to determine the value of the N/5 $CaCl_2$ method. This method, however, possesses one serious drawback—the presence of a large amount of lime in the solution, the last traces of which are difficult to remove, requiring excessive washing to separate the potash. The relatively large amount of lime and small amount of potash in the solution make the determination of the latter quite difficult.

LIME.

The use of carbonated water as a solvent for lime, as proposed by Hallemann (Landw. Vers. Stat. 41), was tested in the Minnesota Experiment Station laboratory, with the following results:

	Soil No. 7. Deficient in lime.	Soil No. 8. Virgin soil, average fertility.	Soil No. 9. Virgin soil, high fertility.
	Per cent.	*Per cent.*	*Per cent.*
CaO	0.018	....	....
	.019	....	....
	.022	0.06	0.80

Fifty grams of soil No. 1 and 100 mg of $CaCo_3$ gave 0.079 per cent CaO, the theoretical per cent, making no allowance for fixation changes, being 0.125. As no other results were received, no conclusion can be drawn regarding the value of this method.

NITROGEN.

[Total nitrogen by official method.]

Analyst.	Soil No. 3.—Deficient in available nitrogen.		Soil No. 4.—Deficient in available nitrogen.		Soil No. 8.—Virgin soil, average fertility.		Soil No. 9.—Virgin soil, high fertility.	
	Total nitrogen.	Humus nitrogen.	Total nitrogen.	Humus nitrogen.	Total nitrogen.	Humus nitrogen.	Total nitrogen.	Humus nitrogen.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Frank Shutt, Canada	....	....	0.049	0.029	0.253	0.156	0.581	0.29
Harry Snyder, Minnesota	0.03	0.01	.046	.017	.25	.168	.59	.25

The use of 3 per cent NaOH as a solvent for the humus nitrogen, after treating the soil with dilute HCl and distilled water, gave concordant and closely agreeing results.

SEPARATION OF COARSE AND MEDIUM SAND.

When the soil samples were distributed it was the plan to procure sieves with circular holes 0.5 and 0.25 mm in diameter for the separation of the coarse and medium sand. To insure accuracy, it was the desire to have the different sets of sieves bored with the same drill, so that the results would be more comparable. No dealer in chemical supplies was found who would agree to make the sieves for less than $100 per set. Sieves made from perforated metal were finally obtained, but they were sent to the analysts too late for any results to be secured. The separation of the various grades of soil particles is a matter which has not been taken up by this association. There are many problems connected with the mechanical analysis of soils which should receive careful consideration.

The diameters of the different grades of particles should be established on a proper basis and not on a conventional one. That is, there should be a constant ratio between the diameters of the different grades of particles. Mr. Hopkins, of the Illinois Experiment Station, proposes as a constant ratio the square root of 10. The adoption of such a scale would enable us to properly define the various grades of the soil particles. The diameters of the different particles should vary according to a constant ratio. At present the ratios of the diameters vary from 2 to 5, which does not place them on a comparable basis.

The adoption of a constant scale for the diameters of the different particles is as important in soil work as the metric system is for chemical work. In the mechanical analysis of soils the results should be given on the basis of the dry soil, as in the chemical analyses, and not on the basis of the air-dry soil.

There are other problems in the mechanical analyses of soils which should also receive attention, but for the present I consider that the two matters mentioned are the most important.

RECOMMENDATIONS.

The following recommendations are offered:

I. That the use of a fifth normal solution of hydrochloric acid, as proposed by Goss, be adopted as a provisional method for the determination of the more active forms of the phosphoric acid in soils.

II. That for the humus nitrogen determination a 3 per cent solution of NaOH be used as a solvent for extraction after treating the soil with 2 per cent HCl and washing with distilled H_2O. This simply defines the strength of the solution and leaves the analyst free to apply the principles in any way that he may desire. It is desirable to have the strength of the solutions defined, so that results will be more comparable. Experiments have shown that more constant results are secured with a 3 per cent solution than with one of any other strength.

III. That the use of $CaCl_2$ and alkaline NH_4Cl as solvents for potash be discontinued, and that for the coming year the so-called International European method for the determination of available potash be given a trial.

IV. That Hallemann's method for the determination of the active lime compounds of the soil be given a further trial during the coming year.

The referees desire to thank the various analysts who have taken a part in the work.

The recommendations of the referee were referred to the committee. The supplemental report on ash analysis was called for, and read by Mr. Hartwell.

SUPPLEMENTAL REPORT ON ASH.

By Burt L. Hartwell, *Associate Referee.*

At the request of the referee on soil and ash analysis I have relieved him of the duties connected with the preparation and mailing of ash samples and compiling and discussing the results obtained from the chemists who have kindly cooperated in the work.

The hay used in obtaining the ashes was taken from the mow, care being exercised that no more dirt be admixed with the ash than may have adhered to the hay in the natural course of curing. It is not probable, under the circumstances, that the sample of ash contained more than 1 per cent of sand. The average amounts of insoluble silica, as determined by the association on the samples of ash distributed during 1895, 1896, and 1897, have been 41.56, 5.98, and 12.05 per cents, respectively. In view of the conflicting results which have been obtained in the separation of soluble and insoluble silica, it becomes very desirable to know the probable amount of foreign material which is contained in the sample distributed, as a guide in questioning reported results. As a large amount of insoluble matter would be out of place in plant ashes intended for scientific investigation, it would seem advisable that care be taken to exclude the same from samples intended for cooperative work.

In the preparation of the ash no precaution was taken by burning at a low temperature to prevent the volatilization of potash and soda. The conditions under which the ignition was carried on were such that the manganese was converted into the form of manganic acid, as shown by the green coloration imparted to the ash and aqueous solution, due to potassium and sodium manganate, and the pink color exhibited, upon the subsequent addition of acid, by potassium permanganate thus formed. The manganese has therefore been recorded in the following analyses as MnO_2, instead of the more usual form of Mn_3O_4.

The following circular letter was sent, with samples of ash, to Elton Fulmer, Pullman, Wash.; F. W. Traphagen, Bozeman, Mont.; Harry Snyder, St. Anthony Park, Minn., and the Division of Chemistry, Department of Agriculture, Washington, D. C., who had expressed a wish for the same:

KINGSTON, R. I., *May 25, 1898.*

DEAR SIR: I send you to-day by mail a sample of ash prepared from a mixed hay, consisting principally of orchard grass (*Dactylis glomerata*). The ash was bottled hot, and a moisture determination should be unnecessary. A complete analysis is desired, following the methods described in Bulletin 46, page 43, Division of Chemistry, United States Department of Agriculture.

Considerable difficulty having been experienced by the association in separating the soluble from the insoluble silica, and as the process is important on account of being essential to the determination of pure ash, a sample has been selected which is rich in soluble silica and will require every precaution for its correct determination. Anyone wishing a more detailed discussion of the method will do well to consult Fresenius's Quantitative Chemical Analysis, pages 420–421, second American edition, where several important precautions are mentioned. Our methods do not specify the amount of water which may be used in connection with the saturated sodium carbonate solution. Two volumes of water to each volume of the saturated solution are recommended. Please state whether the direct or indirect method was used in determining the soluble silica. Caution is necessary, where the amount of silica in the soluble form is as large as in the sample sent, to prevent its changing to the insoluble form at an undesired time.

As no method is given for the determination of iron and alumina in ashes, the following method from Crooke's Select Methods in Chemical Analysis, page 539, second edition, is recommended for trial: The filtrate from the precipitate of ammonium phosphomolybdate obtained during the determination of phosphoric acid is "cautiously neutralized with ammonia, care being taken that the temperature does not rise above 40° C. and that the alkali is added only in slight excess; allow to stand in a warm place until the precipitate completely settles, filter the clear supernatent fluid, wash by decantation, then transfer it to a filter, and finish the washing. The precipitate is dried, ignited, and weighed as ferric oxid and alumina."

Previous to weighing the potassium and sodium chlorids evaporation must be repeated until the residue is completely soluble in water. It is advisable to add a few drops of hydrochloric acid before the final evaporation.

Please report results as soon as obtained, describing any deviations which may have been made from the prescribed methods. Suggestions and criticisms concerning the methods are especially desired.

Yours, very truly,

BURT L. HARTWELL,
Associate Referee.

Ash sample.

Element.	J. K. Haywood, Washington, D. C.	B. L. Hartwell, Rhode Island.	Mr. Hummel, Minnesota.[1]
	Per cent.	*Per cent.*	*Per cent.*
Soluble SiO_2	15.87	15.76	4.18
Insoluble SiO_2	.89	.89	11.88
Total SiO_2	16.76	16.65	16.06
K_2O	36.21	35.42	
Na_2O	3.35	3.70	7.62
CaO	11.97	11.62	
MgO	5.78	5.74	
MnO_2	1.03	.96	
Al_2O_3	.58	.95	
Fe_2O_3	.30		
P_2O_5	9.83	9.90	10.80
SO_3	3.55	3.72	3.64
Cl	12.70	12.56	12.87
C	.14	.06	.89
CO_2	1.03	1.24	1.58
Total	103.23	102.52	
O equivalent to Cl	2.86	2.84	
Corrected total	100.37	99.68	

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[1] These results were obtained by an advanced student, inexperienced in ash analysis, and were not intended to serve as a test of the method.

Mr. Haywood remarks that the "sand and silica were determined together. The sand was then determined with the carbon and subtracted from the combined sand and silicia.

"I find it exceedingly difficult to get rid of the foreign matter in determining the chlorids of sodium and potassium."

Mr. Hummel used the direct method in the determination of soluble silica. He reports that "the K_2O results were unsatisfactory."

I determined the soluble silica by the direct method of evaporating the alkaline filtrate to dryness. Repeated precipitation and evaporation were necessary to obtain the alkaline chlorids in a pure state entirely soluble in water.

As a committee was appointed at the last meeting of this association to carefully rewrite the methods of ash analysis, suggestions from me as to changes in the same would be inappropriate at this time.

In the report of the referee on soil and ash analysis for 1897 the determination of soluble silica was mentioned as being of very doubtful utility, and a recommendation was offered to omit the same. The separation, nevertheless, of soluble from insoluble silica is necessary in obtaining the amount of pure ash in a given sample, i. e., the amount of ash ingredients free from carbon, carbon dioxid, and sand (insoluble silica). An analysis of so-called ash which furnished no indication of the amount of foreign material present would be of doubtful scientific value. The procedure as indicated in the methods of the analysis of the association is, I believe, capable of yielding more uniform results than have been heretofore reported. It may be necessary to introduce into the method such minute directions and precautions as are absolutely essential to correct results before the inexperienced will be able to make a determination which will be looked upon as a test of the method rather than of the chemist.

The method given in the above letter for the determination of ferric and aluminic oxids seems very satisfactory and worthy of further trial.

Opinions agree as to the extreme tediousness in obtaining the chlorids of potash and soda free from impurities in many samples of ashes, and it is hoped that your committee will recommend some changes in the method in this respect.

As considerable difficulty exists regarding the determinations of silica and the alkalies, and as concordant results, if secured, would not necessarily represent the correct percentages of these ingredients, it would seem to be desirable to adopt the idea followed by recent referees on potash and prepare an artificial ash containing known amounts of those consituents the determinations of which are especially worthy of study.

[The methods for the analysis of ashes transmitted by the referee will be found in the revised edition of Bulletin No. 46, Division of Chemistry.]

At the conclusion of the report the president called for papers on this subject, and the following were submitted:

PROBLEMS IN SOIL INVESTIGATIONS.

By Harry Snyder.

Some objections have been raised against the use of HCl, 1.115 sp. gr., as a solvent in soil analysis because it fails to give the available plant food. It is argued that one soil may contain 0.40 per cent potash soluble in HCl, 1.115 sp. gr., and be deficient in available potash, while another soil may contain 0.20 per cent and be liberally supplied. While this is frequently true, it does not follow that HCl has no value as a solvent in soil analysis.

While dilute organic acids and other solvents are valuable to determine the degree of solubility of the materials in the soil, they fail to give any insight into the chemical character of the soil. With the results from both HCl and dilute acids before him, the chemist is able to form a better idea of the true nature of the soil than if either results were considered alone. With HCl as a solvent, if 0.20 per cent CaO and 0.15 per cent Co_2 be obtained, there is no necessity for making an available lime determination with carbonated water. If 0.20 per cent CaO be obtained and only a few hundredths of a per cent CO_2, then there is reason to suspect poverty in available lime.

The hydrochloric acid solvent is valuable in showing an unbalanced condition of the plant food in a soil. For example, let us compare two soils.

	Soil A.	Soil B.
	Per cent.	*Per cent.*
Total insoluble matter	82.40	80.25
K_2O	.40	.25
CaO	.25	.25
P_2O_5	.18	.15
CO_2	.02	.16
SO_3	.01	.03
Total nitrogen	.15	.12
Humus	2.60	1.88

Field tests have shown that soil A is deficient in available K_2O, and that there is no large amount of either available N or P_2O_5. How are the field and laboratory results to be reconciled? Soil A, with 0.4 per cent K_2O, is in need of available K_2O, while B, with 0.25 per cent, is liberally supplied.

In soil A the low per cent of CO_2 and of SO_3 shows that the lime is not present as carbonate or sulphate, while in B it is present mainly as carbonate. In soil B there is a more balanced condition of the elements. The presence of the lime carbonate enables the potash to be utilized, because it furnishes basic material to take the place in the soil of the potash removed in the crop. The conditions are more favorable for active nitrification in B, and the organic matter can not produce acid products. The presence of the neutral organic matter in this soil exerts a favorable influence upon the availability of the phosphoric acid. In soil B there are less of the acid soluble plant food elements than in A, but there is a better balanced condition of the plant food, which renders it more available. The fact that a standard can be established as to the minimum amount of acid soluble plant food a soil should contain does not materially detract from the value of the method. An isolated soil analysis, like an isolated analysis of a well water, may fail to give all of the information desired. When, however, systematic analyses are made of the well waters in any region, valuable results are secured. So with soil analysis, the most valuable results are secured when a number of fertile soils in a locality are examined, and then unknown soils from the same locality are compared with those of known fertility.

Many stations have hesitated to undertake soil investigations, fearing that the results secured would not compensate for the efforts made. If one-half of the energy which is now spent in the analysis of fertilizers were directed to soil investigations, there is no question but that valuable results would be obtained.

In working out methods to determine the degree of solubility of the various plant food elements the methods should apply to all kinds of soils. A significant letter from Dr. Hilgard touches upon this point. He states that in the selection of soils for the association work, virgin soils should be represented, particularly that class composed mainly of silt particles and containing only a small amount of clay particles. In such soils crops feed more liberally upon the mineral matter combined with organic compounds, and ordinary methods for determining available plant food are not applicable to such soils. Grandeau's methods for the analysis of such soils is the most satisfactory one that has yet been proposed.

The joint use of dilute acids to determine the active forms of phosphoric acid and potash; of carbonated water to determine available lime, and, of HCl, 1.115 sp. gr., to give an insight into the chemical nature of the soil, give results which enable the chemist to determine with a fair degree of accuracy the condition of the soil as to available plant food. As to available nitrogen, it would seem best to approach this problem in a different way. The soil should first contain a fair amount of total nitrogen; and, second, the soil should be normal in composition, so that the nitrogen may be rendered available. The total nitrogen, the humus nitrogen, and the lime soluble in carbonated water, when determined and the results are properly interpreted, give valuable indications as to the availability of the soil nitrogen.

The term "active forms of plant food" should be applied to the phosphoric acid and potash soluble in dilute acids, in preference to the term "available plant food," which is so frequently misused in commercial-fertilizer literature.

The acid or basic characteristics of soils are also important matters to consider. In some soils there are excessive amounts of alkaline compounds, while in others there is not a sufficient amount to prevent the formation of organic acids. The methods of soil investigations should be suited to the study of both classes of soils. Methods which are applicable to one class of soil sometimes fail when applied to other soils. For example, soil No. 9 contains 3.15 per cent CaO, and 4.19 per cent CO_2, which make theoretically over 7 per cent $CaCO_3$. When this soil is extracted with NH_4OH for the determination of the free humic acid a dark brown solution is obtained, which, when neutralized with an acid, gives from 0.3 to 0.4 per cent of weighable free humic acid products. When the soil is extracted with carbonated water, 0.8 per cent CaO is obtained. The soil is liberally supplied with lime carbonate, gives an indifferent reaction, and yields 0.3 to 0.4 per cent of so-called free humic acid and produces exceedingly good crops. Evidently the method for the determination of free humic acid is not applicable to this soil.

Another important question in soil investigations is, What standard shall we take for determining the deficiency of any element? Many have answered the question by saying that field tests should be made the standard. But are simple field tests always reliable? To illustrate: Acid phosphate is used and good results are secured; the conclusion is drawn that the soil is deficient in available P_2O_5. The fact that calcium sulphate is an invariable constituent of the phosphate is not considered. The action of the sulphate upon the soil potash and nitrogen may have been equally as important a factor in the crop production as the available phosphate; in fact, field tests are not infallible.

In rewriting the directions for soil analysis the committee appointed at the last meeting of this association should be empowered to simplify the present official method. There is no necessity for first precipitating the lime, then dissolving it and reprecipitating it. One precipitation with careful washing is sufficient. The volumetric method for the determination of CaO should be made an alternate method. The method is a rapid and reliable one; in fact, the ignition of a calcium oxalate precipitate is not an easy matter, as some lime may be reduced to an oxid while part is in the form of a carbonate. There is no special reason why the determination of manganese should be made, and there is nothing gained by making a separation of the iron and aluminia. By making our present method more direct and omitting the unnecessary determinations, soil analysis will be relieved of some of its undesirable features.

DANGER OF DRAWING ERRONEOUS CONCLUSIONS FROM PLANT SOIL TESTS.

By H. J. Wheeler.

The data to be presented here were obtained in connection with a soil test, by means of plants and fertilizers, which has been continued without interruption for nine consecutive years at the Rhode Island Agricultural Experiment Station. The test has been conducted upon eight twentieth-acre plots, separated from one another by paths 3 feet wide. It comprised a plot receiving no manure, one treated with nitrogen, one with phosphoric acid, one with potash, one with nitrogen and phosphoric acid, one with nitrogen and potash, one with potash and phosphoric acid, and one with all three manurial substances. Owing to some inequalities on one portion of the unmanured plot, and to certain irregularities in the treatment of that which received all three manures, their detailed consideration here has been omitted, since it appears unnecessary to the purpose of this paper. It should be stated, however, that almost without exception the best crops have been obtained by the combined use of all three substances, and the poorest ones where no manure was applied, though in certain seasons but little advantage has been gained from the use of either nitrogen or potash when applied singly.

To those plots where the manurial substances were applied either separately or in connection with others the rates per acre for the various years have been as indicated below:

Material.	In 1890 and 1891.	In 1892 and subsequently.
	Pounds.	*Pounds.*
Nitrate of soda	150	480
Dissolved boneblack	350	600
Muriate of potash	150	200

From 1890 to 1893, inclusive, the entire plots were devoted exclusively to maize. In 1894 thirty-seven varieties of plants were employed, two rows of each variety having been run crosswise of the plots, with the hope of obtaining an idea as to whether they would all give similar indications as to the needs of the soil. In pursuance of the same idea, a few of the varieties which gave the most dissimilar results in 1894 were again tested in 1895, 1896, and 1897. In 1895 maize was not included among the plants tested, which explains the absence of results for that year in the succeeding table. On account of the large number of plants employed, the area devoted to maize in 1894 was small, though it was largely increased in 1896 and 1897. Owing to the remarkable character of the results in 1897 the entire plots were once more devoted exclusively to maize in 1898, in order to procure the fullest data possible and to furnish a better comparison with those obtained in the earlier years before other crops were introduced into the experiment.

The following is a tabulation of the results secured with maize during the eight years when that crop was grown:

Table showing the relative weights (in pounds) of maize obtained in a soil test in the years before and after liming the soil.

[In the year 1895 maize was not grown upon the plots.]

Plot No.	Manures.	Yields before liming (corn and stover).					Yields after liming (corn and stover).		
		1890.	1891.	1892.	1893.	1894.[1]	1896.[2]	1897.[3]	1898.
1	Nitrogen	180.0	60.0	60.0	50.0	26.0	10.6	103.3	215.0
2	Phosphoric acid	210.0	129.0	130.0	145.0	88.0	20.8	32.6	130.0
3	Potash	293.8	107.5	61.0	112.5	28.0	11.9	133.8	295.0
4	Nitrogen and phosphoric acid	273.8	139.5	205.0	122.5	116.0	38.5	180.3	350.0
5	Nitrogen and potash	282.5	112.5	88.0	102.5	32.0	26.8	222.5	395.0
6	Potash and phosphoric acid	293.8	157.8	230.0	163.8	202.0	49.2	230.8	335.0

[1] Yield from two rows only, running crosswise of the plots.

[2] Limed in the spring of 1896 and planted immediately. Yield from eight rows only, running crosswise of the plots.

[3] Yield from eight rows only, running crosswise of the plots.

In 1890, as may be seen from the foregoing table, a considerable amount of readily assimilable phosphoric acid must have been at the disposal of the plants, since potash appeared to be the most deficient manurial substance.

From 1891 to 1894, inclusive, the plots receiving single manures, as well as those to which combinations of two were applied, showed without exception that phosphoric acid was by far the most deficient ingredient.

It will be noticed that the results in 1896 (the season in which air-slacked lime was applied to all of the plots at the rate of 2½ tons per acre) point, as in the foregoing years, to a greater deficiency of phosphoric acid than of nitrogen or potash. The two succeeding years, however, the plots receiving single manurial substances only, and those where combinations of two manures were employed, gave every indication that the plants were no longer in great need of phosphoric acid. In fact, in 1898 the yield from the potash and nitrogen plot, where maize had sometimes made but little growth, was the greatest obtained from any of the plots.

Certain cereals, which, like maize, had shown in every particular in 1894 that the soil was most deficient in phosphoric acid, did practically as well in 1895 upon the plot receiving potash and nitrogen as upon that treated with nitrogen and phosphoric acid. However, on account of the fact that they had agreed so thoroughly with maize in 1894, and for the reason that in 1895 the growth upon the nitrogen as well as upon the potash plot was so much inferior to that where only phosphoric acid was used, it was concluded that by mistake potash and nitrogen must have been applied in 1895 to the nitrogen and phosphoric acid plot (No. 4), while the manures intended for that plot were probably applied to plot 5, which should have received nitrogen and potash. Nothing has since transpired to change this view. Even if such an interchange resulted, this factor can not be used as an argument against the conclusion that lime aided by a large amount of moisture was probably the prime agent in producing the remarkable results of the last two years. This is evident when one observes that the yield in 1896 upon the plot receiving nitrogen and potash had again fallen far behind that on the adjoining one which received nitrogen and phosphoric acid. Even if, in spite of this evidence, one were still inclined to attribute the changed character of the results on these two plots in 1897 and 1898 to an after effect due to a possible interchange in the manures in 1895, this would not furnish an explanation of the remarkable growth of the maize in the last two years upon the plots where nitrogen and potash were applied singly.

Taking into consideration, therefore, every objection to such an idea,[1] one is forced to the conclusion that the lime had probably in some way liberated and placed at the disposal of the crop large quantities of phosphoric acid which were formerly almost useless and not in condition to be assimilated by plants. It must be evident from what has been shown that if one has a soil which, for either physical or chemical reasons, needs lime, correct conclusions as to its probable manurial requirement after liming are not likely to be obtained by a soil test from which lime is omitted, and which is continued for but one or two seasons.

Since it would be irrational to attempt to cultivate land sorely in need of lime without resorting to its use, the recognition of the existence or absence of soil acidity as an indication of whether calcium carbonate is deficient or not seems to be a step which should in certain soils precede the inauguration of a soil test.

In virgin soils Hilgard finds that much over 0.1 of 1 per cent of phosphoric acid, as determined from solutions obtained by digesting the soil for five days with hydrochloric acid of 1.115 specific gravity, is enough to insure the profitable production of crops for many years without resort to phosphatic manures. By digestion with acid of the above strength for ten hours, the average of several determinations by members of the Association of Official Agricultural Chemists in the soil of plots 2 and 5 in this test, showed 0.202 and 0.191 per cent, respectively, or about double the amount which Hilgard finds ample for many years in virgin soils. It is apparent, therefore, that the fault of this soil lies not in a small percentage of phosphoric acid, but in the form in which it exists in the unlimed acid soil.

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[1] It is possible that the gypsum in the superphosphate may have exerted a favorable influence upon the growth of the maize, but when one considers that the soil contained more than 0.5 of a per cent of lime (CaO) in various forms, and that in other experiments on adjoining plots the use of air-slacked lime was of no particular advantage to the crop, there seems to be little probability that the wonderful effect from the use of superphosphate before liming could have been attributed chiefly or entirely to the gypsum instead of to the phosphoric acid.

In 1895 this soil was selected by the reporter on soils and ash for the Association of Official Agricultural Chemists on account of its evident deficiency in phosphoric acid, for use in comparative tests for the purpose of obtaining a reliable chemical method by which the manurial requirements of soils long under cultivation could be ascertained. So far as tests with plants had till then shown, a better soil could hardly have been obtained for the purpose, yet after liming it has been found to be but slightly in need of phosphates. This seems to emphasize the fact that a soil test involving the use of potash, phosphoric acid, and nitrogen only may not always prove an accurate guide as to the manurial treatment, nor in the selection of soils designed to serve as a basis for judging of the relative merits of various methods of chemical soil analyses. It appears, therefore, that each plot should probably receive such an amount of lime or other compounds as may, for chemical and physical reasons, be required to put the soil in the best condition in other respects before the test as to relative deficiency of nitrogen, potash, and phosphoric acid is made.

In view of the presence, in many of the States of the Union, of soils lacking calcium carbonate, these factors appear to be worthy of general recognition, since their influence upon the practical and scientific deductions based upon soil tests may in many cases be of great importance.

ESTIMATION OF THE LIME, POTASH, AND PHOSPHORIC ACID IN HAWAIIAN SOILS PROBABLY AVAILABLE FOR THE IMMEDIATE CROP.

By WALTER MAXWELL, *Hawaiian Experiment Station.*

ASPARTIC ACID METHOD.

(1) The hypothetic principle of this method rests upon the assumption that the solvents used shall compare with the solvents that operate in the processes of soil disintegration and plant-food preparation in the field. (See the author's work on the Lavas and Soils of the Hawaiian Islands; also American Chemical Journal, Vol. XX, No. 2, p. 107.)

(2) The standards of control of this method are the ascertained results of the natural processes of soil decomposition in the field, under the conditions of climate and nature of the soils of the Hawaiian Islands, as indicated by the "results of cropping" and "the composition of the waters of discharge" flowing from the land into the sea. (See Lavas and Soils of the Hawaiian Islands.)

(3) The sample is obtained by the mode given in previous publications, viz, by the pipe where this is practicable, otherwise by the spade. The calculation of available matter per acre is based upon the specific gravity (weight of the cubic foot) of the soil and the depth to which the sample is taken. In thin soils the amount is less, in deep soils greater, than the amount found in 1 acre to a depth of 1 foot, upon which depth calculations so far in the use of this method have been based.

(4) The solvent used in this method is aspartic acid. This acid was adopted because it was found that "aspartic acid dissolves phosphoric acid, lime, potash, and other bases (iron and alumina) out of the soil in almost the exact proportions that these elements have been found in the 'waters of discharge,' and in which they are being removed by 'cropping.'" (See Lavas and Soils of the Hawaiian Islands, pp. 179–181.)

(5) The method established and used so far, but which the author may modify in some features, is as follows: Two hundred grams of whole soil (not fine earth), air dried, was put into a glass-stoppered Winchester quart bottle; to this soil were added 1,000 cc of distilled water containing 10 grams of pure aspartic acid, thus making a 1 per cent solution. The bottle was gently shaken every fifteen minutes during the day

portion of twenty-four hours (from 8 o'clock a. m. to 5 o'clock p. m.). By "gently shaken" is meant that the bottle was taken up and shaken in circular movement until the soil at the bottom was totally and thoroughly moved, but without ever rising above the surface of the solution, thus avoiding a remnant of the soil attaching to the sides of the bottle above the solution surface. This explanation is given because it has been shown that in "shaking the bottle containing the soil and solvent, which is the only mode of securing a uniform distribution and action of the solvent, the results of the action will be in large measure proportionate to the mode and vigor of the shaking." (See Lavas and Soils, pp. 136–138.) At the end of twenty-four hours the contents of the bottle were emptied upon a filter, when 750 cc of the clear filtrate was taken for analysis. The 750 cc of filtrate was evaporated to dryness and the residue gently ignited to remove all organic matter. The mineral residue was moistened with hydrochloric acid, evaporated, and dried, then again softened with the same acid, warmed, and taken up with water and filtered. After removal of iron and alumina from the filtrate with ammonia, the lime and potash were estimated in the usual way. The ammonia precipitate, containing also the iron and alumina, was dissolved in a little hydrochloric acid, neutralized with ammonia, the solution cleared with a little nitric acid, after which the phosphoric acid was precipitated and estimated by the common practice.

(6) The estimation of the amounts of the elements that are "probably available for the immediate crop" is drawn from the foregoing analysis: As "a 1 per cent solution of aspartic acid takes out of Hawaiian soils in twenty-four hours the same amounts of lime, potash, and phosphoric acid that are removed during the production of ten crops of cane, therefore one-tenth of these amounts may be taken as a nearest approach to the proportions of lime, potash, and phosphoric acid that are available for the immediate crop." (See Lavas and Soils, p. 181.)

As it has been said, the principle of this method rests upon the assumption that the solvent used shall compare with the solvents that are actually operating in nature; and that the standards of control of the results of this method are the ascertained results of the natural processes of soil—decomposition in the field. Not any consideration has made it appear advisable to the author that a solvent should be used which is not found amongst the acids that result from vegetable existence and decay, and which consequently is not used by nature in the field. It has, on the other hand, appeared to him absolutely necessary that, before concluding that the results obtained by the use of any artificial method of examination are rational and of any authority and value, these results should be subjected, if possible, to comparison with the standard of results actually following from the processes operating in the field.

A PLEA FOR A SCIENTIFIC BASIS FOR THE DIVISION OF SOIL PARTICLES IN MECHANICAL ANALYSIS.

By C. G. Hopkins.

The following is the system of divisions which appears to be rapidly coming into use in mechanical soil analysis:

Division No.	Size of particles.
	mm in diameter.
1	> 1
2	1 to .5
3	.5 to .25
4	.25 to .1
5	.1 to .05
6	.05 to .01
7	.01 to .005
8	< .005

These limits were originally chosen by mere chance and have no more of a scientific basis than have the common systems of weights and measures or the Fahrenheit thermometer scale. They were first employed by Dr. Thomas B. Osborne in a study of methods of mechanical soil analysis and were not intended by him to be used in a practical study of soils. Regarding this, Dr. Osborne says:

"In working out the beaker method of soil analysis I employed the limits of the various grades with reference simply to convenience in using my eyepiece micrometer. I have always thought that the limits of the various grades should be determined by a careful consideration of the various conditions involved in the problem of proper mechanical analysis of a soil, and have been surprised to see that the arbitrarily chosen limits of the various grades employed by me have been followed by others in applying the method in practice."

The one very serious objection to this system is that the ratio of the diameter of the largest particles to that of the smallest particles in each of the various divisions is not a constant. In divisions 2, 3, 5, and 7 the ratio of largest to smallest diameter is 2 to 1; in division 4 the ratio is 2.5 to 1, while in 6 the ratio is 5 to 1. As a consequence of this wider ratio, division 6 will receive twice as much soil as division 4 and two and one-half times as much as either 2, 3, 5, or 7 from a sample whose particles are in uniform gradation. In practical work, as a rule, a much larger percentage of soil is found to fall in division 6 than in either 5 or 7, and this is plainly not due to any peculiarity of the soil, but to the simple fact that by definition the limits for division 6 are two and one-half times wider than those of either contiguous division.

The following table shows the ratios of diameters, of surfaces, and of volumes of the limiting soil particles in each division except those at the ends of the series. It also gives the theoretical composition of a sample which is made up of soil particles of uniform gradation between the limits of gravel and clay, assuming the end divisions to contain the average percentage.

Division No.	Size of particles (mm.).	Ratio of diameters.	Ratio of surfaces.	Ratio of volumes.	Theoretical percentage composition.
1	> 1				12.50
2	1 to .5	2 to 1	4 to 1	8 to 1	9.68
3	.5 to .25	2 to 1	4 to 1	8 to 1	9.68
4	.25 to .1	2.5 to 1	6.25 to 1	15.6 to 1	12.10
5	.1 to .05	2 to 1	4 to 1	8 to 1	9.68
6	.05 to .01	5 to 1	25 to 1	125 to 1	24.20
7	.01 to .005	2 to 1	4 to 1	8 to 1	9.68
8	< .005				12.50
Total					100

The differences in the ratios of the largest to the smallest particles in the several divisions become even larger when we consider surfaces or volumes instead of diameters, and yet such phenomena of soil physics as capillarity and porosity are in relation to the surfaces or volumes of soil particles rather than to their diameters. It will also be observed that the percentages of soil in the different divisions vary from 9.68 to 24.20, although by theory the soil is of uniform gradation.

Because of this objection to the common system of making the divisions in mechanical soil analysis, the system illustrated in the following table was worked out by the writer some two years ago. It was subsequently adopted by the department of soil physics of the University of Illinois, and has since been employed with entire satisfaction.

The table shows the theoretical composition of a soil whose particles are in uniform gradation within the limits of the system, assuming the end divisions to contain the average percentage. Ratios of largest to smallest particles are also given.

Division No.	Name of particles used.	Size of particles (millimeters).	Ratio of diameters.	Ratio of surfaces.	Ratio of volumes.	Theoretical percentage composition.
1	Gravel	> 1				12.50
2	Coarse sand	1 to .32	3.2 to 1	10 to 1	32 to 1	12.50
3	Medium sand	.32 to .1	3.2 to 1	10 to 1	32 to 1	12.50
4	Fine sand	.1 to .032	3.2 to 1	10 to 1	32 to 1	12.50
5	Coarse silt	.032 to .01	3.2 to 1	10 to 1	32 to 1	12.50
6	Medium silt	.01 to .0032	3.2 to 1	10 to 1	32 to 1	12.50
7	Fine silt	.0032 to .001	3.2 to 1	10 to 1	32 to 1	12.50
8	Clay	< .001				12.50
	Total					100

The square root of 10 (approximately 3.2) is adopted as a common factor in passing from smallest to largest particles in all divisions of defined limits, and thus the ratio of the largest to the smallest particles becomes a constant; this applies to the ratios of diameters, of surfaces, and of volumes. Every division receives the same percentage of a soil of uniform gradation. This system employs 0.001 mm (diameter) as the limit of separation between fine silt and clay. (By the use of centrifugal force, as described in another paper, this separation is rendered entirely practicable.) Three grades of silt are thus determined instead of two as by the ordinary system, while the four grades of sand usually determined are here condensed to three, although the limit of separation between sand and silt is practically the same in either system. Both systems employ as limits of divisions 1, 0.1, and 0.01 mm (diameter), and it is important to note that, by combining the percentages obtained in practical work so as to make four divisions instead of eight, the two systems become identical and of course strictly comparable to that extent.

With the proper accessories the microscopic measurements are made with the same degree of convenience and exactness in either system.

The important fact should be mentioned that the new system readily admits of expansion. By taking the fourth root of 10 (approximately 1.8) instead of the square root of 10, each of the limited divisions is simply divided into two equal divisions. This will make a series of fourteen separate divisions of soil particles and the system still retains all of the advantages which have been mentioned. The following form is recommended for use with the expanded system:

Division No.	Name of particles.	Size of particles (millimeters).
1	Gravel	> 1
2	Coarse sand	1 to .56 .56 to .32
3	Medium sand	.32 to .18 .18 to .1
4	Fine sand	.1 to .056 .056 to .032
5	Coarse silt	.032 to .018 .018 to .01
6	Medium silt	.01 to .0056 .0056 to .0032
7	Fine silt	.0032 to .0018 .0018 to .001
8	Clay	< .001

A RAPID METHOD OF MECHANICAL SOIL ANALYSIS, INCLUDING THE USE OF CENTRIFUGAL FORCE.

By C. G. Hopkins.

A sample of 10 grams of soil is placed in a small sieve having circular perforations 0.32 mm in diameter. (Such a sieve is easily made by carefully enlarging the perforations of a 0.25 mm sieve with a drill of 0.32 mm diameter.) The sieve is placed in a porcelain evaporator and the fine earth washed through with successive portions of water. The sieve should reach nearly to the bottom of the evaporator. The gravel and coarse sand remain in the sieve (under water) and are rubbed with a rubber pestle till clean from the fine earth, which is gradually transferred with the successive portions of water from the evaporator to a bottle of 500 cc to 600 cc capacity.

The gravel and coarse sand are dried, separated by a millimeter sieve, ignited, and weighed.

The bottle containing the fine earth and 300 cc to 400 cc of water is placed in a shaking machine similar to that described by Professor Whitney in Bulletin No. 4, page 9, Division of Soils, United States Department of Agriculture. The bottle is shaken for a length of time deemed to be sufficient for complete disintegration of the soil. About 125 cc of the contents of the bottle are then transferred to a flat-bottom glass cylinder about 40 mm in diameter and 160 mm high. The cylinder is placed in the centrifugal machine and whirled until all particles coarser than 0.001 mm diameter have been thrown to the bottom. The length of time necessary to accomplish this depends upon the diameter and speed of the machine. It must be determined by experiment for each machine with microscopic measurement of the particles remaining in suspension. With a machine of about 60 cm diameter and a speed of about 3,000 revolutions per minute not more than five minutes are required for this process.

A rubber stopper carrying two glass tubes similar to those used in the ordinary wash bottle is placed in the mouth of the cylinder, the longer tube reaching nearly to the bottom. By blowing in the shorter tube the water and suspended clay are transferred to a large beaker or bottle almost completely without disturbing the sediment. The sediment is then well stirred up, or "pestled," by means of a stout glass rod covered at the end with a rubber cap. Another portion of the contents of the shaking bottle is transferred to the cylinder, which is closed with a close-fitting solid rubber stopper and thoroughly shaken, the stopper being carefully rinsed off with fresh water. The cylinder is then whirled as before and the suspended clay removed. This is repeated until all of the fine earth has been transferred to the cylinder, fresh water being used as needed to complete the transfer. The sediment is again stirred up and shaken with fresh water, the cylinder whirled in the machine, and the suspended clay removed with the water, as before. This process is repeated until it is found that nothing remains in suspension with the speed and time adopted. The addition of a small amount of ammonia at the time the sediment is "pestled" is commonly recommended as hastening the process of separating the clay from the coarser particles. It has been used by the writer with apparent advantage.

The "clay water" will usually amount to three or four liters if the separation of clay is carried to a high degree of accuracy. It is evaporated in a large platinum or porcelain dish to a small bulk, the clay being then transferred with a small quantity of fresh water to a smaller dish, evaporated to dryness, ignited, and weighed.

The sediment remaining in the cylinder is shaken with fresh water and then whirled in the machine, preferably at a somewhat reduced speed, for a length of time sufficient to throw to the bottom all particles coarser than 0.0032 mm diameter, and the suspended fine silt removed with the water as already described. This process is repeated until nothing remains in suspension after whirling.

By further reducing the speed or time (or both) the medium silt, 0.01 to 0.0032 mm diameter, is also separated, after which gravity is substituted for centrifugal force, and first the coarse silt, 0.032 to 0.01 mm diameter, and then the fine sand, 0.1 to 0.032 mm diameter, removed, thus leaving in the cylinder only the medium sand, 0.32 to 0.1 mm diameter.

If the removal of clay has been complete, no "pestling" is necessary in making the subsequent separations.

The waters containing the medium and fine sand and the three divisions of silt are allowed to stand until the sediments have completely subsided. The clear water can then be removed by siphon almost completely. (It may be saved to be used again.) The various sediments are transferred to evaporators with small amounts of water, and after evaporating to dryness they are ignited and weighed.

Two analyses are carried on together and there is some advantage in carrying four samples at a time through the clay separation.

Moisture and organic matter are determined in another sample of 10 grams, and the mechanical analysis is then reduced to the basis of ignited soil, which is believed to be the only basis upon which such analyses are strictly comparable.

The following is a record of some of the analyses which the writer has made by this method and it is believed that it fairly represents its accuracy, although the error appears to be much less than is common in mechanical soil analysis:

Divisions.	Soil 1.	Soil 2.	Soil 3.	Soil 4.	Soil 5.	Soil 5.
Gravel	0.07	0.19	....	....	1.06	1.06
Coarse sand	1.54	1.64	0.44	1.03	6.36	5.83
Medium sand	6.91	7.66	1.52	3.78	29.01	28.71
Fine sand	7.28	7.64	3.98	8.38	9.43	9.64
Coarse silt	42.99	45.14	32.61	45.01	21.40	22.03
Medium silt	12.25	16.05	16.48	19.01	10.88	10.70
Fine silt	11.55	9.22	10.08	11.44	6.04	6.14
Clay	16.97	12.08	34.44	10.78	15.30	15.56
Total	99.56	99.62	99.55	99.43	99.48	99.67

The high degree of accuracy of this method is doubtless attributable to several conditions:

(1) A direct determination is made of the total clay.

(2) The total amount of water employed in a complete analysis is comparatively small.

(3) Analyses are easily completed on the next day after they are begun.

In all of these points the method differs essentially from the ordinary methods of mechanical soil analysis.

When it is understood that by the use of centrifugal force work may be done in five minutes' time which gravity will not accomplish in twenty-four hours, the value of this method is more fully appreciated.

It should be stated that, soon after this method had been worked out, the writer learned that Prof. Harry Snyder, of the University of Minnesota, was also using centrifugal force in mechanical soil analysis, although to a more limited extent than in the method herein described.

After the reading of the papers and a somewhat extended discussion, the report of the committee on recommendations was presented as follows:

SOILS AND ASH.

Your committee recommends the adoption of the first recommendation of the referee on soils and ash.

The committee recommends that the process described in the second recommendation of the referee be adopted as a provisional method.

The committee also recommends that the use of calcium chlorid as a solvent for potash be abandoned, that neutral or alkaline ammonium chlorid be given a further trial, and that for the coming year the so-called International European method for the determination of available potash be given a trial.

The committee also concurs in the fourth recommendation of the referee.

All the recommendations of the committee were unanimously approved.

The report of the referee on foods and feeding stuffs was then called for. The referee, Mr. W. H. Krug, read the following report:

REPORT ON CATTLE FEEDS.

By William H. Krug, *Referee.*

The work of Dr. Lindsey, the referee for the year 1897, had conclusively shown that all methods proposed for the estimation of starch, in which the material is directly subjected to the inverting action of acids, yield results which are above the actual starch content on account of the simultaneous conversion of the pentosans into pentoses and the galactan into galactose. He therefore recommended that the diastase method be made the provisional method for the determination of starch in all substances except in commercial starch and in potatoes. This recommendation was adopted, and the work on the determination of starch for this year was accordingly limited to the diastase method, as it seemed desirable, under the circumstances, to obtain as many results as possible by this method, whereby it would be given a severe test. It gives me pleasure to state that this has been to some extent realized, thirteen chemists reporting results obtained with the method.

The phenylhydrazin and phloroglucin methods for the estimation of the pentosans have again been compared and the method recommended for the estimation of galactan has been tried.

Three samples were sent out, No. 1 consisting of barley, No. 2 of bran, and No. 3 of red-clover seed. These materials were ground as fine as possible, thoroughly mixed, and immediately bottled and sealed.

In answer to the circular letter sent, 17 chemists agreed to cooperate with the referee. Twelve have returned reports.

I. The Estimation of Starch.

The provisional method, as adopted at the last session of the association, is described in the proceedings for the year 1897.

Samples 1 and 2 were chosen for the comparative work on this method, as the former consisted of a material rich in starch while the latter contained a relatively small amount of starch and a high percentage of pentosan.

The following table contains the results obtained on these samples:

TABLE 1.—*Results obtained with the diastase method.*

Analyst.	Barley.		Bran.	
	Air-dry sample.	Calculated to dry matter.	Air-dry sample.	Calculated to dry matter.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*
E. B. Holland, Mass. Exp. Station	66.58	73.70	8.39	9.11
C. D. Howard, N. H. Exp. Station	63.59	69.57	9.80	10.58
C. H. Jones, Vt. Exp. Station	68.49	75.62	[1]18.33	[1]19.79
G. L. Teller and J. F. Moore, Ark. Exp. Station	68.60	78.29	7.00	7.81
W. H. Heileman, Wash. Exp. Station	[1]57.06	[1]63.16	6.94	7.47
H. J. Patterson, Md. Exp. Station	[1]53.61	[1]59.81	[1]0.69	[1]0.74
F. S. Shiver, S. C. Exp. Station	66.17	72.92	8.56	9.24
H. C. Sherman, Columbia College, N. Y	63.84	71.33	11.01	12.01
O. C. Beck, Columbia College, N. Y			10.92	11.92
H. Fisher, Columbia College, N. Y			11.38	12.42
R. G. Wright, Columbia College, N. Y	64.72	71.64		
S. S. Munson, Mich. Exp. Station	[1]53.73	[1]60.57	7.78	8.56
W. H. Krug, U. S. Dept. of Agr	65.45	72.76	7.88	8.61
Averages	65.93	73.23	8.97	9.77

[1] Excluded from the averages.

NOTES ON THE ESTIMATION OF STARCH.

E. B. Holland, Massachusetts.—The residues, when treated with iodin and examined microscopically, showed considerable starch in No. 1 and only a trace of starch in No. 2. The cuprous oxid was collected in sugar tubes and oxidized by heating in a continuous current of oxygen.

C. H. Jones, Vermont.—I found it necessary to use 90 cc of diastase solution to change all the starch.

G. L. Teller and J. F. Moore, Arkansas.—The work being so long delayed, freshly ground samples of fresh malt were substituted for that sent. The digestion with acid was carried on by putting the flasks in a box well supplied with hot steam and maintaining them at or near the temperature of boiling water for two and one half hours. Each flask was supplied with an open tube about three feet long, most of the tube being above the steam box. The precipitated copper was collected on asbestos in glass tubes and reduced in hydrogen.

W. H. Heileman, Washington.—The moisture determinations were made by the regular association method. The samples were extracted with ether previous to making the starch determinations. The copper was weighed as metallic copper, having been deposited electrolytically from a dilute nitric acid solution. The malt solutions were made for each determination. The malt was standardized by the same processes as those used in estimating the starch. The malt solutions were always fresh and of uniform strength. After washing the samples with alcohol, as directed, they were dried each time on the water bath, to entirely free them from alcohol, and were afterwards immersed in a boiling water bath with 50 cc of water, as directed. I found difficulty in knowing when the diastase had converted all the starch. Forty cc of malt solution were used for sample No. 1 and 20 cc for sample No. 2.

H. C. Sherman, Columbia University, N. Y.—In all cases after treating with malt solution until the starch reaction had disappeared, the solution was boiled and again tested for starch. If the latter were found, the treatment with malt extract was repeated.

S. S. Munson, Michigan.—With the diastase method for starch a fresh extract was made up for each determination, as at the beginning it was found that the extract was ineffective after having stood two days. This method gave results that duplicated very closely in both cases. In sample No. 2 there was no reaction with iodin after thirty minutes, whilst sample No. 1 required about ninety minutes to completely convert the starch

DISCUSSION.

An examination of the data as calculated to dry matter reveals as great a variation from the mean as was exhibited in last year's work. This variation may be at least in part ascribed to the difference in the amount of moisture as found and used for calculating the results of the basis of dry matter. The following table contains these results:

TABLE 2.—*Moisture determinations.*

Analyst.	No. 1.	No. 2.	No. 3.
	P. ct.	*P. ct.*	*P. ct.*
E. B. Holland, Mass. Exp. Station	9.68	7.90	7.11
C. D. Howard, N. H. Exp. Station	8.59	6.79	
C. H. Jones, Vt. Exp. Station	9.43	7.35	
G. L. Teller and J. F. Moore, Ark. Exp. Station	12.37	10.27	9.03
W. H. Heileman, Wash. Exp. Station	9.66	7.47	
H. J. Patterson, Md. Exp. Station	10.20	7.89	7.33
F. S. Shiver, S. C. Exp. Station	9.26	7.40	6.63
H. C. Sherman, Columbia University, N. Y	10.50	8.32	
O. C. Beck, Columbia University, N. Y		8.37	
H. Fisher, Columbia University, N. Y		8.40	
R. G. Wright, Columbia University, N. Y	9.66		
S. S. Munson, Mich. Exp. Station	11.30	9.10	8.05
W. H. Krug, U. S. Dept. of Agr	9.91	8.42	7.67

The influence which such differences may exert is most strikingly shown in the results obtained by Mr. Jones and by Messrs. Teller and Moore, where the data given for the original material agree very satisfactorily, while the same results calculated to dry matter vary by 2.67 per cent.

The direct results obtained are, with the exception of the figures which have been excluded from the averages, quite satisfactory. The most plausible explanation for the low figures obtained in some cases is that the gelatinized starch had not been completely dissolved by the diastase, and therefore escaped the final inversion. Lintner and others have shown that the disappearance of the iodin reaction in the solution can not be accepted as proof of the total conversion of the gelatinized starch into soluble products, and German chemists determine this point by a microscopic examination of the residue. This is without doubt much more rational and certain, since it is but logical to assume that the starch suspended in the liquid is more rapidly and easily converted by the diastase than that which is partially or wholly surrounded by cell walls. It seems to me that we may here seek one of the causes of the deviations which have heretofore characterized the results obtained by this method, and that this source of error should be removed by determining the total conversion of the starch by means of a microscopic examination of the residue. This is easily done, and requires but a moment.

Another source of error may be sought in the solubility of the pentosans when the material is treated by the diastase method. König[1] first took up this subject, and published a number of results which showed that these bodies were partially dissolved. The matter was then investigated by Dr. Wiley and myself,[2] our data indicating that only small quantities of the pentosans were soluble. Lintner[1] subsequently published an article on the determination of starch in cereals, in which he states that he finds the pentosans to be appreciably dissolved, but ascribes this rather to the action of the boiling water than to hydrolysis by the diastase. An analysis of barley is given, there being found 63.66 per cent of starch. The solution contained 2.84 per cent of pentosans (less pentosans present in the malt extract), giving as the true starch content 60.82 per cent. The same material was then inverted directly with acid according to the Sachsse method, the total reduction in terms of starch being 70.81 per cent. The solution contained 9.81 per cent pentosans, giving as the starch content 61 per cent. On account of the difference in the reducing power of the pentoses and dextrose these figures do not represent the true amount of starch present. The author assumes this to be slight, however, as he found that when a solution containing dextrose and the sugars obtained from the pentosans was fermented the unfermentable residue had a reducing power of 5.13 per cent in terms of starch, and the pentosans were found to be 5.19 per cent. He therefore considers it admissible to deduct the pentosans from the total reducing power stated in terms of starch.

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[1] Landw. Versuchsstat, 48 (1896), 81.

[2] Journ. Am. Chem. Soc., 20, 4, 266.

Accepting the above as true, it can be easily understood that any variation in the time of treatment with diastase would result in the solution of different amounts of pentosans, and would thereby influence the final result very materially. The following results, which I obtained by a modification of the diastase method in which the gelatinized material was treated one hour at 50° with 20 cc of malt extract, boiled thoroughly, cooled, and again treated for an hour at 50° with 20 cc of malt extract, when starch could not be detected in the residue, indicate that this actually occurs:

TABLE 3.—*Results obtained with modified diastase method.*

Sample No.	Starch in air-dry material.
	Per cent.
1	67.29
2	13.33

A comparison of these data with the results which I obtained on the same materials by the provisional method, shows an increase of 1.84 per cent in the starch content of sample No. 1 and of 5.45 in the starch content of sample No. 2. This is just what we would expect if König and Lintner's statements are correct and the increased amount of pentosans which has been dissolved by the second boiling is more marked in sample No. 2, which contains a high percentage of pentosans as compared with sample No. 1. I am, however, not prepared to accept this explanation as final, since it does not seem to me to be based on sufficient analytical data.

The use of an increased quantity of malt extract gives rise to another error in the final result. Wroblewski has recently shown that diastase consists of a proteid combined with araban, the mother substance of arabinose. The error which is caused in this manner is necessarily small when the provisional method is adhered to, but increases with the amount of malt extract used.

Slight differences in the final results are no doubt caused by the fact that the copper was not weighed in the metallic state in all cases. In connection with this subject I wish to call attention to a new method of reducing the oxid which has been devised by Breshus.[2]

The cuprous oxid is collected on a filter, washed thoroughly, the filter partially dried between filter paper, transferred to a small weighed platinum dish, heated to remove the water, and ignited. The dish is previously prepared by heating it to ignition, adding 1 cc of methyl alcohol drop by drop, allowing it to cool partially, and placing it in the balance case. When the filter has burned, the mass of cupric and cuprous oxids is moved to one side as much as possible, and the dish is covered with a lid, which has an opening in the center with depressed edges. It is heated to bright redness, and 1 cc of methyl alcohol is run in drop by drop. The flame is then removed and another cc run in. The vapors of methyl alcohol and formaldehyd are ignited, and as soon as they cease burning the cover is removed and the dish placed in the balance case to be weighed when cold. The operation must be repeated when any doubt exists with reference to complete reduction. Andrlik and Hraniĉka[1] have suggested a modification of this method, in which they use a Gooch crucible, prepared as follows: The bottom is covered with asbestos, on which is placed a perforated platinum disk with a short platinum wire to facilitate its removal. This is in turn covered with a layer of asbestos. The double filter thus formed is washed with alcohol and the crucible dried and weighed. The cuprous oxid is collected and washed with hot water and alcohol. The crucible is then placed in a larger solid crucible, which is slowly heated until the Gooch crucible is at a red heat. It is then immediately transferred to a small beaker, the bottom of which is protected by means of copper gauze, and which contains some methyl alcohol. The beaker is covered with a watch glass. The crucible is removed when cold, dried for ten minutes in a water oven, and weighed. Comparative determinations have shown this method to be practically as accurate as the asbestos-tube method.

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[1] Zeitsch. angew. Chem., 1898, 725.

[2] Neue Ztsch. Rübenzuck.-Ind., 41, 1, 4.

RECOMMENDATIONS WITH REFERENCE TO THE DIASTASE METHOD

It is recommended that—

(*a*) The quantity of material to be used be changed to 3 grams.

(*b*) In the first line the words "with ether, bring the extracted residne onto a filter or into a Gooch crucible, and" be stricken out, and the words "on a hardened filter, with five successive portions of 10 cc of ether," be substituted.

(*c*) In the sixth line and following, the words "until the solution no longer gives the starch reaction" be stricken out, and the words "until a microscopic examination of the residue with iodin reveals no starch" be substituted.

(*d*) That in the tenth line the word "exactly" be changed to "nearly," and the words "avoiding excess" be stricken out.

SUGGESTION.

It is suggested that the solubility of the pentosans be made the subject of further study in connection with the diastase method.

II. THE ESTIMATION OF PENTOSANS.

In accordance with the suggestion contained in the report of the referee for 1897 the work consisted of a further comparison of the phenylhydrazin and phloroglucin methods. Both methods have been described fully in the last Proceedings of the Association.

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[1] Zeitsch. Ver. Rübenzuck.-Ind. deutsch. Reichs, 47, 1077.

The following table contains the results obtained:

TABLE 4.—*Comparative results with phenylhydrazin and phloroglucin methods.*

Analyst.	Barley.				Bran.			
	Original material.		Calculated to dry matter.		Original material.		Calculated to dry matter.	
	Phenylhydrazin method.	Phloroglucin method.	Phenylhydrazin method.	Phloroglucin method.	Phenylhydrazin method.	Phloroglucin method.	Phenylhydrazin method.	Phloroglucin method.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
E. B. Holland, Mass. Exp. Station	3.08	4.34	3.41	4.81	25.77	26.85	27.98	29.15
C. D. Howard, N. H. Exp. Station	......	3.92	......	4.29	....	27.80	....	29.83
Teller and Moore, Ark. Exp. Station	......	5.15	......	5.88	....	27.80	....	30.98
H. J. Patterson, Md. Exp. Station	......	2.95	......	3.29	....	23.88	....	25.92
F. S. Shiver, S. C. Exp. Station	4.79	3.96	5.28	4.36	26.13	25.80	28.22	27.86
C. H. Jones, Vt. Exp. Station	......	3.42	......	3.78	....	[1]19.67	....	[1]21.23
S. S. Munson, Mich. Exp. Station	3.53	4.32	3.98	4.87	[1]19.28	24.42	[1]21.21	26.86
W. H. Krug, U. S. Dept. of Agr	3.89	4.42	4.32	4.90	25.02	26.37	27.32	28.79
Averages	3.82	4.06	4.25	4.52	25.64	26.13	27.84	28.48

[1] Excluded from the averages.

NOTES ON THE ESTIMATION OF PENTOSANS.

H. J. Patterson, Maryland.—I found it impossible to obtain constant weight by drying from three to four hours. With sample No. 1 it required about twice that time, and with sample No. 2, I dried for ten hours.

F. S. Shiver, South Carolina.—In regard to the determination of the pentosans I would say that I allowed the solutions, after precipitation with the phenylhydrazin acetate, to stand twenty-four hours in all cases; then filtered, and washed in the usual way. The hydrazone precipitate was then dissolved in strong alcohol, the alcohol evaporated, and the residue dried at 50° to 60° C. to constant weight. I found the method as described in your circular unsatisfactory for two reasons, viz, the impossibility of removing all portions of the precipitate from the beaker, and also the incomplete precipitation of the hydrazone in the half hour specified.

C. H. Jones, Vermont.—If my pentosan results are low, it is probably due to the nature of the flame used in the distillation. This, I am just informed, should be so regulated that no charring of material occurs on the sides of the flask.

S. S. Munson, Michigan.—In both methods for determining pentosans it was impossible to obtain results that duplicated closely. The phloroglucin method invariably gave higher results than the phenylhydrazin method. With sample No. 1 the distillate usually gave a reaction with anilin acetate until about 400 cc had passed over; with No. 2 until about 450 cc had distilled over. In the phenylhydrazin method it was found necessary to let the solution stand for some time before filtering, in order to secure complete precipitation.

DISCUSSION.

The table shows that the phloroglucin method has almost uniformly given higher results, only one chemist reporting a higher percentage of pentosan by the phenylhydrazin method than by the phloroglucin method. This was obtained by allowing the solution to stand for twenty-four hours before filtering.

I have not been able to discover any cause for this uniform discrepancy, but am inclined to ascribe it to an incomplete removal of the furfurol-hydrazone from the beaker in which it has been precipitated. The precipitate is often of such a nature that when it has become attached to the sides of the beaker it is a matter of extreme difficulty to remove it completely. The crystals, when rubbed with a feather or glass rod, break up into a tarry mass, which persistently adheres to the glass and can not be detached. I do not think that the difference is due to an incomplete precipitation of the furfurol-hydrazone, as the phenylhydrazin method has been thoroughly studied with known amounts of furfurol and the factors which are used are based on the results of these studies.

The differences which occur between the results obtained with the phloroglucin method by the individual chemists may be due to several causes. Stift[1] has lately published an article on the determination of the pentosans by the phloroglucin method in which he shows that even the phloroglucin purissimum of Merck generally contains considerable quantities of diresorcin, and reports comparative analyses, made with impure and purified phloroglucin, which show deviations amounting with bran to as much as 0.28 per cent. According to Zeisel, the diresorcin may be removed by shaking with an equal volume of pure ether (20 grams of phloroglucin, 20 cc of ether) and washing the residue with ether until it no longer gives a violet color when dissolved in a few drops of acetic anhydrid heated and mixed with 1 to 2 drops of concentrated sulphuric acid. The phloroglucin dissolved by the ether can be recovered by distilling off the ether and purifying the residue, as before.

The influence which the presence of diresorcin exerts on the result has been the subject of considerable discussion, and Tollens and Krüger have found that small quantities do not impair the accuracy of the method. This is of some importance, as the purification is expensive. It is evident, however, that some limit should be placed on the amount of diresorcin present, especially when we consider that Councler found Merck's phloroglucin purissimum to contain from 7.59 to 14.63 per cent. Such amounts seriously vitiate the results, as the diresorcin is only difficultly soluble in hydrochloric acid of 1.06 specific gravity. Merck has now introduced a phloroglucin free from diresorcin, and I think that this or a similar preparation should always be used, and that, as a matter of precaution, the test above described should be applied.

Variations in the method of distillation cause errors, which, according to Stift, amount to as much as 1 per cent of furfurol. In a subsequent article Komers and Stift[2] recommended that the distillation be carried out at 140° to 160° in a bath of Rose's metal, at which temperature the distillate amounts to about 30 cc every ten minutes. I believe that the present method of distillation is deficient, as it is liable to cause a certain amount of charring or caramelization on the sides of the flask, which is quite difficult to prevent and will result in a variable loss. I have, unfortunately, not been able to make comparative tests on this point, but think it worthy of investigation.

I wish to call attention to the new factors which have been adopted by Krüger and Tollens for the conversion of the phloroglucid into furfurol and which are based on a series of determinations made with known amounts of furfurol and phloroglucin. They are as follows:

Phloroglucid (less than and up to 0.2 gram) ÷ 1.82 = furfurol.
Phloroglucid (from 0.2 to 0.3 gram) ÷ 1.895 = furfurol.
Phloroglucid (from 0.3 to 0.4 gram) ÷ 1.92 = furfurol.
Phloroglucid (above 0.4 gram) ÷ 1.93 = furfurol.

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[1] Oesterr. ungar. Zeitsch. Zuckerind. und Landw., 27, 19.

[2] Neue Zeitsch. Rübenzuck. Ind., 39, 7, 77.

I also wish to point out that the formulæ which are given for the conversion of the furfurol into pentosans do not agree with those given by Krüger and Tollens,[1] whose investigations led them to adopt the following for the phloroglucin method:

I. (Furfurol — 0.0104) × 1.68 = xylan.
II. (Furfurol — 0.0104) × 2.07 = araban.
III. (Furfurol — 0.0104) × 1.88 = pentosan.
IV. (Furfurol — 0.0104) × 1.91 = xylose.
V. (Furfurol — 0.0104) × 2.35 = arabinose.
VI. (Furfurol — 0.0104) × 2.13 = pentose.

The same authors have adopted the following formulæ for the phenylhydrazin method:

I. Hydrazone × 0.516 + 0.0104 = furfurol.
II. Hydrazone × 0.8681 = xylan.
III. Hydrazone × 1.0671 = araban.
IV. Hydrazone × 0.9676 = pentosan.
V. Hydrazone × 0.9865 = xylose.
VI. Hydrazone × 1.2126 = arabinose.
VII. Hydrazone × 1.0995 = pentose.

RECOMMENDATIONS.

It is recommended that—

(*a*) A phloroglucin free from diresorcin be specified for the precipitation of the furfurol.

(*b*) After the phloroglucid has been collected on the Gooch crucible, the action of the aspirator be continued for half an hour.

(*c*) The sentence "In case there is very little furfurol in the substance treated," etc., be stricken out.

(*d*) The time of drying be made three and a half to four hours.

(*e*) The following method for testing the phloroglucin be incorporated in the provisional method: Dissolve a small quantity of the phloroglucin in a few drops of acetic anhydrid, heat almost to boiling, and add a few drops of concentrated sulphuric acid. A violet color indicates the presence of diresorcin. A phloroglucin which gives more than a faint coloration must be rejected.

(*f*) That the factors adopted by Krüger and Tollens be substituted for those at present in use.

SUGGESTION.

It is suggested that the influence which variations in the method of distillation exert on the yield of furfurol be investigated.

III. THE ESTIMATION OF GALACTAN.

The work consisted of a comparative study of the method proposed by Dr. Lindsey in the report for 1897. I subsequently found that Mr. Holland had determined the galactan both in the original material and after it had been extracted with ether. This appeared to be an important improvement, and I accordingly made a similar comparison and requested Mr. Teller, the associate referee, to do likewise.

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[1] Zeitsch. angew. Chem. 1896, pp. 36–46.

The following table contains the results:

TABLE 5.—*Results obtained with the galactan method.*

Analysts.	Original material.		Extracted material.	
	In original substance.	Calculated to dry matter.	In original substance.	Calculated to dry matter.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*
E. B. Holland, Mass. Exp. Station	8.14	8.76	9.33	10.04
G. L. Teller and J. F. Moore, Ark. Exp. Station	8.18	9.00	9.38	10.30
H. J. Patterson, Md. Exp. Station	[1]5.16	[1]5.57	....	....
F. S. Shiver, S. C. Exp. Station	9.33	9.99	....	....
S. S. Munson, Mich. Exp. Station	7.11	7.73	....	....
W. H. Krug, U. S. Dept. of Agr	7.67	8.31	9.01	9.76
Averages	8.09	8.76	9.24	10.03

[1] Excluded from the averages.

NOTES ON THE ESTIMATION OF GALACTAN.

G. L. Teller and J. F. Moore, Arkansas.—The weight of mucic acid obtained was much more constant for different determinations when the material was previously extracted with ether than when it was not.

F. S. Shiver, South Carolina.—The galactan determinations were not as satisfactory in my hands as they might be, quite large differences being found.

S. S. Munson, Michigan.—In the determination of galactan closely duplicating results were secured.

DISCUSSION.

It is seen that previous extraction with ether increases the percentage of galactan found quite materially and results in more uniform work. It is without doubt a valuable improvement and worthy of adoption.

RECOMMENDATION.

It is recommended that—

The provisional method for the estimation of galactan be amended so that the first line shall read, "Extract 3 grams of the finely powdered substance on a hardened filter with five successive portions of 10 cc of ether, bring the extracted residue into a beaker," etc.

An extended discussion of the report was engaged in by the members, with especial reference to the determination of carbohydrates and organic acids. It was pointed out that in the reports of the analyses of feeding stuffs the organic acids were usually omitted. It was further pointed out that if all the different constituents known already to exist in feeding stuffs be determined, the summation of the data of the analysis approximates very nearly 100 per cent. This is especially true of cereal grains, but in cases of fodders, hays, straws, etc., the discrepancies are still somewhat large.

The president then called for the report of the referee on food adulteration. In the absence of the referee, Mr. W. S. Sweetser, the secretary read his report:

REPORT ON FOOD ADULTERATION.

By W. S. SWEETSER, *Referee.*

GENTLEMEN: Your referees decided that the time had come when some attention might be given profitably to the comparison of some of the laboratory methods employed in this branch of analytical work. The subject of starch determination in spices was selected, not because it is the most important determination made in the detection of adulteration, but because the subject seems to be so open to investigation and is one this association is investigating in other relations.

Invitations to cooperate in this work were sent out in the spring, but only a very few favorable replies were received. The work laid out was of a nature to require but a little time, yet very few of the chemists to whom these invitations were sent were in a position to undertake the work. Three lots of whole spices—nutmeg, Jamaica ginger, and Singapore pepper—were reduced to a very fine state in the Menker fodder mill. The samples were not sifted. They were tightly corked and sealed and sent to the different laboratories with the following directions:

I. DIASTASE METHOD.

STARCH.

Exhaust 3 grams of the substance with ether and treat the residue on a Gooch with 10 per cent alcohol till the soluble matter is extracted, wash with strong alcohol, bring the dried residue into a 250 cc flask with 50 cc of water, immerse flask in a boiling-water bath, stirring the contents constantly until the starch gelatinizes; cool to 55° C. and add 40 cc of malt extract and maintain this temperature until the solution no longer gives the starch reaction with iodin. After cooling make up to 250 cc, filter, and invert 200 cc in a 10 oz. flask with 20 cc of 25 per cent HCl, sp. gr. 1.125, connect with a reflux condenser and heat in a boiling-water bath for two hours, cool, and when milk-warm neutralize carefully with NaOH (avoiding an excess), clarify, if necessary, with 10 to 20 cc of alumina cream, and make up to 500 cc. Mix well, pour through a dry filter, and determine dextrose in an aliquot part by Allihn's method. Convert dextrose to starch by the factor 0.9.

Preparation of malt extract.—Digest 10 grams of fresh, finely ground malt over night at ordinary temperature with 200 cc of water and filter. Determine the amount of dextrose in a given quantity of the filtrate after boiling with acid, etc., as in the starch determination, and make the proper correction..

II. DIRECT INVERSION.

STARCH.

Exhaust 3 grams of the substance with ether, treat the residue on a Gooch with 10 per cent alcohol, and then with strong alcohol; dry, transfer to a flask, add 200 cc of water and 20 cc HCl, sp. gr. 1.125, connect with a reflux condenser, and boil for four hours. Filter out the residue and accurately neutralize the filtrate with NaOH. Clarify, if necessary, with alumina cream. Mix well, run through a dry filter, and determine dextrose in an aliquot part by Allihn's method. Convert dextrose to starch by the factor 0.9.

In addition to the starch determinations by these two methods, the analysts were requested to determine volatile oil by the method considered preferable and to report the method in detail. The following results and notes were received:

Analyst.	Nutmeg.					Ginger.					Pepper.				
	Moisture.	Volatile oil.	Fixed oil.	Starch, diastase.	Starch, direct inversion.	Moisture.	Volatile oil.	Fixed oil.	Starch, diastase.	Starch, direct inversion.	Moisture.	Volatile oil.	Fixed oil.	Starch, diastase.	Starch, direct inversion.
	P. ct	P. ct	P. ct.	P. ct.	P. ct.	P. ct.	P. ct	P. ct	P. ct.	P. ct.	P. ct.	P. ct	P. ct	P. ct.	P. ct.
C. D. Howard, Durham, N. H	....	3.03	35.10	20.72	25.63	.....	1.47	3.12	51.97	57.57	.....	1.22	7.23	39.15	41.73
W. L. Mitchell, New Haven, Conn	....	3.87	38.29	.....	.....	.....	1.49	3.04	.....	.....	.....	.90	7.31	.....	.....
C. A. Browne, jr., State College, Pa	9.74	....	.....	25.13	25.46	11.39	....	....	54.04	58.24	10.93	....	....	38.21	43.45

NOTES.

C. D. Howard.—In the determination of volatile oils 3 grams were extracted from twenty-five to twenty-eight hours in a Johnson continuous extractor. The extract was transferred to a 50 cc beaker and exposed over night and then dried over H_2SO_4 and pumice stone to a constant weight, which was difficult to obtain. It was then dried a short time at 80° C. and finally two hours at 110° C. The loss was called volatile oils and the residue fixed oils. No difficulty was experienced with the starch work except in filtering the alcohol extract from the pepper.

W. L. Mitchell.—The method used for ether extract was that described by Richardson, Bulletin No. 13, Division of Chemistry. Two grams were extracted twenty hours with ether without previous drying. After allowing the ether, etc., to evaporate spontaneously in a capsule, the residue was dried twelve hours over H_2SO_4, thus giving the total extract. The loss after drying to a constant weight at 110° C. was called volatile oil and the residue non-volatile ether extract. A second extraction of ten hours gave the following per cents of non-volatile ether extract: Pepper, 0.15; nutmeg, 0.13; ginger, 0.11.

Dr. A. L. Winton gives the benefit of some of his experience along this line of work. He used twelve samples of pepper—black, white, shells, long, etc.—and treated each according to the two methods described above. His first difficulty was with the malt extract. Standing over night it invariably soured, owing to the warmth of the laboratory. It seemed necessary to fall back to the old plan of digesting three hours at 40° C., and using as soon as possible. In each case 4 grams of the washed pepper were digested four hours at 55° C., with 50 cc of the malt extract. The bulk of the liquid, which was 100 cc at the beginning of the digestion, 50 cc starch paste and 50 cc malt extract, was increased to 150 cc at the end of the third hour to remove the paste adhering to the sides. At the end of the fourth hour the solutions gave no blue with iodin, and the analyses were finished in the manner directed. Unfortunately, he found, when too late, that there was still undissolved starch in the solid part of the pepper, and the fact that the results were from 5 to 8 per cent lower than by the direct inversion was largely due to this cause. Time was too limited to follow the matter up before this meeting.

Fine grinding aids in the malt digestion, but renders the preliminary washing very difficult and so slow that fermentation is liable to set in. Then, too, there is danger of loss of starch mechanically, especially with those spices whose starch grains are very minute.

Longer digestion with the malt might be more effective, but there might be the possible danger of the malt beginning to ferment by protracted heating at 50° to 55° C.

Interrupted digestion is also suggested. This plan is to digest with a certain amount of malt extract for one hour, then boil, add more malt extract, after lowering to the proper temperature, and digest again. This process could be repeated. The boiling would probably render the starch more gelatinous and easily acted upon than the mere heating in a bath of boiling water. This plan of interrupted digestion seems worthy of some attention, especially with those spices which should not be ground very fine.

Your referee suggests that this subject receive further attention, and that these two methods of starch determination, with some modifications, be applied side by side to spices quite low in starch content, such as cayenne, cloves, and mustard.

In the examination of such material, a quick, accurate method for the determination of starch would be valuable.

The president called for papers on the subject. None having been presented, the discussion of the subject was declared to be in order.

Mr. W. D. Bigelow said he was much interested in this matter and would be glad to hear from the president of the association, who had lately done a great deal of work, on spices especially. The great object of the study, of course, is to enable one to judge of the purity of the spices offered for sale. These spices often have starch added as an adulterant, for instance, wheat starch. There should be some standard on a subject of this kind, and he understood that the president was engaged in work which might lead to the establishment of just standards for spices and condiments of all descriptions. The present methods of examination seem to be too tedious. Shorter and yet reasonably accurate methods should be devised, if possible. Perhaps it might be sufficient to make a hydrolysis of the spice and polarize it directly, or the diastase solution might be polarized directly. Such a method, while not at all accurate, might be satisfactory for sorting purposes.

The president said he was very full of this subject. He came from a State which was supposed to be the original home of the fabrication of nutmegs, and was naturally interested in spices and condiments of all kinds. He said he had samples at his hotel of spices and condiments which he would gladly bring up and show to the association, having collected a great number for analytical purposes.

The method in use by him was to determine the oils, ash, water, and alcohol extract, nitrogenous bodies, and in addition to this special microscopic examinations. A great many adulterations of spices were in the way of the use of exhausted spices, such as ginger. The microscope has no value in discriminating between exhausted and non-exhausted spices. In England the custom is to determine the cold-water extract, starch, etc. Full reports of the president's work will be found in later publications of the Agricultural Experiment Station of Connecticut, food adulteration department.

Mr. H. A. Huston called attention to the fact that the manufacturers and dealers should have their names on the packages of spices, so that they could be identified.

Mr. Bigelow called attention to the desirability of publishers of chemical books printing their advertisements on cards similar to those used for library purposes, so that these advertisements might be conveniently filed. The association voted to concur in Mr. Bigelow's suggestion.

The president begged leave to call the attention of the association to the death of one of its associate referees, namely, Dr. Charles P. Worcester, of Boston. Dr. Worcester was in ill health at the time he accepted the position of associate referee, but was so much interested in the work that he consented to do the best possible. Death, however, brought his career to an untimely end. The president asked the members, as a tribute to the memory of the late Dr. Worcester, to rise in their places.

The president appointed the following committee on nominations for offices for the next year: Messrs. Scovell, Ross, and Frear. The president then declared the convention adjourned until afternoon.

SATURDAY—AFTERNOON SESSION.

On the reassembling of the association the president called for the report of the committee on recommendations of referees. The committee presented its unanimous report in favor of the recommendations of the referee of foods and feed stuffs. The report was adopted.

The report on dairy products was then called for, and it was read by the referee, Mr. C. L. Penny, as follows:

REPORT ON DAIRY PRODUCTS.

By C. L. Penny, *Referee.*

The work on which assistance was asked from members of the association for this year is outlined in the following circular letter:

Association of Official Agricultural Chemists.

METHODS FOR THE ANALYSIS OF DAIRY PRODUCTS.

Your cooperation is requested in studying the following methods for the analysis of dairy products:

I.—*Volatile acids of butter fat.*

1. Compare the provisional method of saponification, using a reflux tube or condenser (Circular 4, p. 3), with the official method prescribing a closed flask.

2. Compare with the official method of saponification the Leffmann-Beam method, using, if possible, both fresh and rancid butter. (See Analyst, Vol. XVI, p. 153; Vol. XVII, p. 65 and p. 176, and Vol. XXI, p. 259.)

II.—*Casein in milk.*

1. Modification of provisional method 1. (Acetic acid method, Circular 4, p. 3.) "Carry the method through as described to the washing of the precipitate, then neutralize the filtrate as exactly as possible with caustic alkali; filter off any precipitate that may form and add it to the former precipitate for the nitrogen determination."

2. Alum method: "To 10 cc of milk add 50 cc of water at 40° C. Then add 1.5 cc of an alum solution saturated at 40° C. or higher. If the precipitate fail to settle promptly, add half a cubic centimeter more of the alum solution, filter, wash with water, and use Kjeldahl method for nitrogen."

III.—*Albumin in milk.*

Modification of provisional method: "To the filtrate from the casein, according to either of the above methods, add 10 cc of strong tannin solution; heat, filter, wash with water, and determine nitrogen."

The proposed work on milk is suggested by the last referee, Dr. Van Slyke. Samples of milk will be sent to you for the casein and albumin if you are willing to cooperate in that part of the work.

C. L. Penny, *Referee.*

Newark, Del., *April 29, 1898.*

I. VOLATILE ACIDS OF BUTTER FAT.

1. CONDENSER VERSUS CLOSED FLASK.

Your referee was directed to investigate the propriety of using a flask attached to a reflux condenser for the saponification of fats in place of the closed flask. Dr. Weems, of the Iowa Station, found a Reichert number of 20.65 by the present method with closed flask, and 20.75 with condenser, each result being a mean of two determinations. Mr. C. H. Jones, of the Vermont Experiment Station, found, working with four different samples, higher results with the condenser in the case of two, viz, 0.15 cc and 0.31 cc higher, respectively, and in the case of the other two, higher results with the closed flask, viz, 0.31 cc and 0.38 cc higher, respectively. The mean of the four is 0.03 cc higher with the closed flask, and this must be regarded as complete concordance. It will appear from this that nothing is lost by the use of the condenser, as the average results agree perfectly. As the ethyl butyrate, whose escape is feared, boils at about 120, the condenser would seem to fulfill the extreme of precaution, and in fact to be more certain than the secure closing of a flask to withstand an internal pressure of over an atmosphere. It is probable that most of the experience on volatile acids has been gotten with the use of a condenser, as that seems to be the method in more general use. It is questionable, however, whether the open flask on a water bath, as prescribed by König in his Agricultural Analysis (Landwirtschaftliche v. Gewerb. Stoffe, 403), is not entirely too incautious. It would seem from the results given above and from general experience to be unquestionably as safe to use a condenser as a closed flask. I have no hesitation in recommending to the association the adoption of this provisional method as official.

2. LEFFMANN-BEAM SAPONIFICATION METHOD VERSUS THE OFFICIAL REICHERT-WOLLNEY METHOD.

About six years ago the attention of the association was directed to the Leffmann-Beam saponification method. In the light of some analytical results presented at that time no favorable recommendation touching its adoption was made, and beyond discussion no action was taken. Since then no official report has been made to the association on the subject.

This method, as is well known, consists in heating in an open flask over a direct flame the butter fat with a solution of caustic soda in glycerol. The saponification takes place very rapidly and at a temperature considerably above 100°; in fact, it appears to be almost instantaneous as compared with the Reichert-Wollney method. Water is added at once to the soap thus formed, then dilute sulphuric acid, when the distillation is begun without previous melting of the fatty acids. Thereafter everything is as in the official method.

The advantages of the glycerol method are so obvious to anyone who has tried it that little need be said. When it is remembered that the official method advises one hour for saponification proper, and for solution of free fatty acids a time varying from a few minutes to several hours, the saving of time by the glycerol method is enormous, reducing to five minutes at most what requires one or more hours. It is doubtful if any other analytical method have been devised within recent years that so greatly abridges a process as does this one. So easy is it in the execution, furthermore, that the only question as to its precedence of all rivals is as to the results obtained.

It is much to be regretted that fuller original experimental data can not be laid before the association, but I have available only the results of Dr. Weems and my own.

Dr. Weems found 20.21 cc decinormal soda as a mean of two determinations for 5 grams of fat, using 20 cc of a 5 per cent solution of soda in glycerol, and again 20.32 cc decinormal soda using 10 cc of a 12 per cent glycerol solution. The official method gave as a mean of two determinations 20.65 cc decinormal baryta. Apparently two different standard solutions were used for the titration, soda for the new method and baryta for the old. The discrepancy is 0.39 cc less by the glycerol method.

My own results are as follows:

On a single sample of fresh butter four repetitions by the official method averaged 28.80 cc and three by the Leffmann-Beam 28.63 cc, a shortage for the latter of 0.17 cc. In a series of comparative tests on 10 different samples from ten to fourteen months old, and consequently rancid, the official method averaged 0.78 cc above the Leffmann-Beam. In 14 similar comparisons of 11 samples all less than a month old, the official method averaged 0.49 cc above the other. Thus the Leffmann-Beam method seems to give slightly lower results than the official method, on a general average of the above figures 0.35 cc for fresh samples and, as just stated, about 0.78 for rancid samples.

Two questions may with propriety be asked: First, is this shortage an error? and, second, if it be an error, is it a material one? The Leffmann-Beam method requires the sample and reagent to be heated considerably above 100° (as judged by the explosion of the refluent drops of water) before the reaction sets in. During this raising of the temperature there is doubtless a certain loss of free volatile acids. Is this a defect or a merit? By the official method such escape can not occur except during the prolonged heating of the original butter sample "at about 60° for two or three hours" when such escape does unquestionably occur, especially with rancid samples. What are these free volatile acids? Are they on the one hand original constituents of the pure natural butter fat or liberated from the same, or, on the other hand, are they fermentation products of non-fatty bodies left in butter, as casein, milk sugar, and lactic acid? If these free volatile acids have been liberated from butyrin with separation of glycerol, they ought to be counted in the final distillate. If they have been formed by fermentation from lactic acid or milk sugar they are as much foreign to butter fat as is cottonseed oil, and they ought to have no place in the distinction of butter fat from other fats. Or, to apply the question directly to the end in view, in the sum total of volatile acids taken as characteristic of butter fat should the free volatile acids of the original sample be included? There are arguments on both sides. It has been found that butter after a long time, as several years, loses a little of its total volatile acids, a fact seeming to indicate that everything volatile should be counted; whereas there is doubtless a shorter time after making when the sum of volatile acids is increased by fermentation products of the sugar and lactic acid, bodies less stable than the fats and more readily split up. To take evidence from practical life, the readiness with which poorly worked butter becomes rancid seems to emphasize the fact of an accession of volatile fatty acids from a non-fatty source. As a choice between uncertainties, since to the analyst the age and other conditions of a sample are supposed to be unknown, I am of the opinion that the Reichert number should be understood to represent combined volatile fatty acids, with exclusion of the free. Should this view obtain, the slight shortage by the Leffmann-Beam method would not be considered a defect. It would seem that the official method ought to aim at one thing or the other, either to count all of the volatile acids, free and combined, or to count only the combined. At present it does neither. The melting of the sample at 60° for two or three hours is, of course, attended with some loss of free acids, as may easily be detected by the sense of smell. If it be designed to include such acids as characteristic of butter fat, then the preliminary official method of treating the butter sample calls for revision.

As to the second question: If any deficiency as compared with the official results be assumed an error, is it a material one? It must be remembered in considering the Reichert distillation that we are dealing with something practically of high utility but logically incomplete and fallacious, in that the distillate obtained is but a fraction of the characteristic body present in the sample, and furthermore, a fraction variously estimated, under different manipulation, as low as 80 per cent and as high as 87 per cent, so that the distillation alone from the same soap might vary by one-twelfth or by 2 cc or more. (See Analyst XX, 218, and Allen, Organic Anal., II, 45.)

If there be any mode of reasoning repugnant to the true scientific spirit, it is this inference from an unknown part to the whole. The only justification in this instance is the lack of something better. The practical end aimed at is attained with as much certainty as fluctuations in natural butter fat will permit, and that, in default of something better, is enough.

It must be clear that the vulnerable point of the entire Reichert method is the distillation, not the saponification, the uncertainty as to the precise fraction that is distilled over. This uncertainty has been reduced so far as possible by the prescription of volume of liquid to be boiled, volume of distillate, time of boiling, etc. But there still remain unfixed conditions and practically unfixable, in the atmospheric pressure, shape of flask, etc., so that after the soap has been formed, the acids liberated and melted, if the solution were given to different chemists to distill there might be expected results varying as widely as any we find in our comparative tests. These differences between comparative tests are, however, slight. Let anyone compare them with the results obtained by different chemists on the same sample of phosphoric acid, for example, and it will be seen that this method, incomplete and fractional as it is, compares favorably in concordance with some of the oldest and best tried methods of analytical chemistry.

It must furthermore be borne in mind that the present application of the volatile acids determination is to distinguish genuine butter fat from other fats. When it is remembered that the Reichert number for genuine butter fat has been found to vary as much as 2 to 1, from 34 cc decinormal alkali to less than 15 cc, it will be clear that a close discrimination between butter fat and other fat, or a quantitative determination of a mixture of each, must be within wide limits of possible variations, so wide, in fact, that the discrepancies here presented are hardly as great in practical effect as the errors of a good balance, i. e., they are nothing. What rational chemist would dare to say that a sample giving a Reichert number of 20 is genuine and another giving one of 19 is adulterated? Such arbitrary decisions have been made, it is true. With the confidence that inexperience alone gives, it was held that any result below a fixed Reichert number should indicate adulteration, and the proportion of the adulteration was to be determined as certainly as by the rule of three. But widening experience with the vagaries of nature in the making of butter fat reduced this number from 28 to 26, to 24, even to 20. Unfortunately, Spallanzani found samples below 15. These are, for the sake of the analyst's assurance, regarded as abnormal (though how he shall say that his unknown sample may not also be abnormal, but genuine, is not clear). At all events the quantitative result of the Reichert method aims primarily at a qualitative conclusion, the question of more or less being a minor one. In this it differs from almost all other analytical processes. A judgment passed upon the general Reichert method that ignores this vital distinction is erroneous. It is a mistake to assume that analytical fluctuations have the significance here that they have in phosphoric acid determination for example, where analyses fix money values in strict proportion, though, as was said, the method under discussion will bear the comparison. The consideration of the value of a method ought to regard its application as well as its inherent qualities. In the light of all that can be ascertained I do not hesitate to recommend to the association for its unqualified adoption the Leffmann-Beam saponification method.

II. CASEIN IN MILK.

Two modifications of the present method have been proposed: First, the neutralization of the acetic acid filtrate, in order to obtain a second precipitate which is to be added to the main precipitate; second, the precipitation of casein with a saturated solution of alum instead of acetic or other acid. The comparative analytical results which follow are somewhat fragmentary, in that the several analysts have not covered the same ground, yet some inference may be drawn.

CASEIN AND ALBUMIN IN MILK.

Analyst.	Total N × 6¼.	Casein.			Albumin.		
		Provisional method.	Acetic filtrate neutralized.	Alum method.	Provisional method filtrate.	Neutralized filtrate.	Alum filtrate.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
C. H. Jones, Vt. Exp. Station.	3.37	....	2.78	2.73	....	0.40	0.59½
	3.41	....	2.79	2.69	....	.39	.62
	3.41	....	2.76	2.66	....	.38	.63
	3.40	....	2.78	2.69	....	.39	.61½
I. J. Meade, Iowa Exp. Station	....	[1]1.62	....	[1]1.94	0.66	....	.60
J. A. Le Clerc, Geneva, N. Y., Exp. Station.	3.26	2.68	2.80	2.68	....	....	....
	....	2.69	2.81	2.69	....	....	....
	....	2.75	2.81	2.74	....	.40	.44
	....	2.68	2.80	2.77	....	.42	.44
	....	2.75	2.88	2.83	....	.43	.45
	....	2.71	2.82	2.74	....	.42	.44
C. L. Penny, Del. Exp. Station	....	2.64	....	2.61	....	....	....
	....	2.59	....	2.60	.50½	....	....
	....	2.59	....	2.61	.55	....	....
	....	2.61	....	2.61	.53	....	....
G. E. Patrick and T. C. Trescot, U. S. Dept. of Agr.	....	....	2.56	2.44	....	.46	.56
	....	....	[2]3.21	2.44	....	.45	.56
	....	....	[2]3.25	2.44	....	.45	.56
	....	....	2.44	2.50	....	....	.58
	....	....	2.56	2.44	....	.47	.56
	....	....	2.52	2.45	....	.46	.564

[1] Presumably an arithmetical error, the percentage of nitrogen being unknown to the referee.

[2] These two results, evidently erroneous, were inexplicable to the analysts and were therefore reported; but they are not included in the average.

As to the modification of the acetic method (consisting in neutralizing the acid filtrate with caustic alkali and recovering any precipitate that may have formed) Mr. Le Clerc finds an increase of 0.11 per cent while I could not detect a second precipitate. The alum method is found by Messrs. Jones and Le Clerc to give from 0.08 to 0.09 per cent less than the modified acetic method, and by Messrs. Patrick and Trescut 0.07 per cent less, while I find equal results.

III. ALBUMIN IN MILK.

As to the determination of albumin by means of a strong tannin solution, the results range from 0.66 by Mr. Meade to 0.39 per cent by Mr. Jones, discrepancies influenced somewhat, though not wholly caused, by the nature of the filtrate from which the tannin precipitation was made. Without further comment on the results and without recommendation I offer a suggestion for future investigation, viz: That the total nitrogen be determined directly; that a relatively large quantity of milk, as 75 grams, be diluted about fivefold and be treated according to the alum method in liter flask and made up to the mark; in an aliquot of the filtrate from this let the nitrogen be determined and (multiplied by 6.25) let it be counted as albumin; let the casein be found by difference. This would dispense with the washing of the casein, which is a tedious process. If there be any nitrogenous body in milk properly included neither in that which acetic acid and alum precipitate nor in that which tannin precipitates, it must be present in minute proportion; it is hard to see what advantage can accrue from so extended a subdivision of the proteids in milk, even should the actual existence of a number of such bodies other than casein and albumin seem to justify that step. By far the readiest way, then, of determining the casein and albumin would seem to be to count for albumin all proteids that the alum does not precipitate and to deduct this from the total sum of proteids. By this method there would be but a single precipitation, no washing of a precipitate, and two determinations of nitrogen, the total and the albuminous. The results of Mr. Le Clerc, added, show the casein plus albumin to be within 0.02 per cent and 0.08 per cent of the total proteids; Mr. Jones finds the sum of casein and albumin to fall 0.23 per cent and 0.10 per cent short of total proteids, a result due to his higher figure for total nitrogen rather than to lower figures for casein and albumin.

RECOMMENDATIONS.

(1) That after the last line on page 27 of the Methods the following be inserted: "(a_2) The fat prepared as above may also be weighed into the saponification flask from a weighing tube marked to contain 5.75 cc."

(2) That the provisional method of saponification, given in the fifth paragraph of page 3, Circular No. 4, be made optional.

(3) That after the first full paragraph on page 29 of the Methods the following be inserted:

LEFFMANN-BEAM METHOD.

(1) *Reagents.*

(*a*) GLYCEROL-SODA SOLUTION.—Add 20 cc of a 50 per cent solution of sodium hydroxid to 180 cc pure concentrated glycerol. The soda must be as free from carbonate as possible.

(*b*) SULPHURIC ACID.—Make up 200 cc of concentrated sulphuric acid to 1 liter.

(2) *Saponification and distillation.*

About 5 grams of fat are weighed into a flask and 20 cc of the glycerol-soda solution added. The flask is then heated over a Bunsen burner until complete saponification takes place, as evidenced by the mixture becoming perfectly clear, the whole operation requiring less than five minutes. The soap is then dissolved in 135 cc of water, preferably previously boiled, the water being added at first drop by drop, to prevent foaming; 5 cc of the dilute sulphuric acid are added and the distillation is carried on at once, as usual, without the previous melting of the free fatty acids.

At the conclusion of the reading of the report papers were called for, and none being presented, discussion followed on the subject of the melting points of fatty acids before distillation. It was the general consensus of opinion that it was not necessary to wait for a complete fusion of the fatty acids before beginning the distillation, but that the distillation might begin as soon as the acid was added and the soaps entirely decomposed.

Attention was called by Mr. Scovell to the fact that if only just enough acid be added to neutralize the alkali it requires a longer time to melt the separated fatty acids, while the addition of an excess of acid facilitates the fusion.

It was stated by Mr. Hand that for the ordinary quantities employed 25 cc are usually enough.

It was stated by Mr. Penny that the quantity of acid and alkali employed in the Leffmann-Beam method was the same as with ordinary procedure.

The committee on recommendations here presented its report in favor of the recommendations of the referee on dairy products. The report was adopted.

The PRESIDENT. The hour of 2 o'clock having come, the special order is the election of officers for the ensuing year. I therefore call upon the committee on nominations for a report.

Mr. SCOVELL. Mr. President, your committee on nominations begs to submit the following recommendations:

For president, Mr. R. C. Kedzie, of Michigan; for vice-president, Mr. B. W. Kilgore, of Mississippi; for secretary, Mr. H. W. Wiley, of Washington; for additional members of the executive committee, Mr. H. J. Wheeler, of Rhode Island; Mr. B. B. Ross, of Alabama; Mr. William Frear, of Pennsylvania.

The secretary was instructed to cast the ballot of the association for the nominees of the committee. The secretary reported that he had cast the unanimous ballot of the association in favor of the candidates named.

The report of the referee on sugar was next called for. The referee, Mr. R. S. Hiltner, then presented the following report:

REPORT ON SUGAR ANALYSIS.

By R. S. HILTNER, *Referee.*

As there has been no work done by the association on sugar analysis and no official report on the subject for the last two years, it is possible that many members have lost track of the lines of work in progress previous to that time. On this account, before discussing the work of the present year, a brief résumé of the work already done on the subject may not be out of place.

As gleaned from published reports of proceedings and from correspondence with our secretary, Dr. Wiley, the work that has been carried on may be summed up as follows:

At the fifth annual meeting the first report of the committee on sugar was read. The committee simply suggested general methods for the analysis of juices, molasses, etc. There was no formal report on sugar at the sixth convention, but a paper was read by Mr. B. B. Ross, in which he described experiments in the redetermination of Clerget's constant. At Dr. Wiley's suggestion, the methods of the Louisiana Sugar Association were adopted provisionally. Subsequent to the sixth meeting the work of the association has been confined largely to the methods of desiccation of various products. The "double polarization" methods and determinations of ash have also received some attention.

It is but a truism to state that sugar analysis is a broad field and that there yet remains much valuable work to be done in the investigation of both beet and cane products. The real difficulty in the way of rapid progress in this work is not a scarcity of material nor of subject matter, but rather a lack of time. Unfortunately, few members of the association can spare the time required by such work.

Of late years the demand upon the time of the station chemist has been so varied and the pressure of routine work so great as to considerably retard aggressive work for the association, and consequently the interest in many of the branches has considerably lagged. The effect of this has been keenly felt in arranging the work on sugar analysis this year. Of the 55 stations only 16 chemists offered to assist in this work, and of these only 4 reported results. The almost unanimous reason for declining to take part in the investigation was "lack of time." This state of affairs is greatly to be regretted, because the value of our association work depends, to a very large degree, upon the number included in the averages.

For the work on sugars for the year the chemists of the association were asked to cooperate in analyzing some sugar-beet products. This work was undertaken on the suggestion of several chemists interested in sugar analysis. In view of the probable increase in the extent of the beet-sugar industry in the Northern and Western States it was thought desirable that the association should adopt at an early date analytical methods applicable to such products.

To be sure, many of our official methods that apply to cane-sugar products apply equally well to sugar-beet products. Moreover, the same difficulties in the way of obtaining accurate concordant results are met with in both classes of material. The difference, however, in chemical composition of the juices of the two sugar-bearing plants, cane and beet, and the difference in the processes used in the manufacture of sugar from them, result in factory products and by-products that differ widely in composition and characteristics, both chemical and physical. For example, the molasses from cane-sugar factories contains sucrose (about 35 per cent), reducing sugars (about 10 per cent), but no raffinose, while, on the other hand, the average sugar-beet molasses contains about 50 per cent sucrose and 0.4 per cent to 3 per cent raffinose, but little or no reducing sugars. This, of course, necessitates different analytical methods.

The material selected for the experimental work was a sample of sugar-beet molasses furnished by Supt. W. H. Baird, of the Norfolk Beet Sugar Factory. This molasses, a dark, viscid liquid, is rich in sucrose, contains a large percentage of ash and organic matter not sugar, as well as raffinose and a small amount of reducing sugar. It was considered, therefore, that this substance would represent in a general way the beet-sugar by-products, and that also, because of its complex composition, it would illustrate the difficulties in the way of obtaining accurate results.

The suggestions made by the referee for the analysis of the molasses were as follows:

I.—*Determination of water and total solids.*

(*a*) Determine per cent of water by the Carr and Sanborn method, which has been adopted, provisionally, by the association.

The drying may be conducted in a water oven at ordinary pressure or in vacuo.

(*b*) In a flat-bottom dish place 6 or 7 grams of pure quartz sand and a short stirring rod. Dry thoroughly, cool in a desiccator, and weigh. Then add 3 or 4 grams of the molasses, mix with the sand, and dry at the temperature of boiling water for eight to ten hours. Stir at intervals of an hour, then cool in a desiccator and weigh. Stir, heat again in the water oven for an hour, cool, and weigh. Repeat heating and weighing until loss of water in an hour is not greater than 3 mg.

This sample may be used for the determination of ash by the Alberti-Hempel method. (See Method II (*d*) under "Ash.")

The sand used should be pure quartz. It should be digested with strong HCl, washed, dried and ignited, and kept in a stoppered bottle.

II.—*Determination of ash.*

(*a*) Weigh 5 to 7 grams of molasses in a flat-bottom porcelain or platinum dish. Saturate with concentrated sulphuric acid, heat cautiously until the acid is driven off and until intumescence ceases, then ignite in a muffle at low redness. Subtract one-tenth of the weight of the ash and calculate per cent.

(*b*) Place in a porcelain dish 6 or 7 grams fine quartz sand and a short stirring rod, heat to redness, cool in a desiccator, and weigh. Then weigh into the dish 3 or 4 grams of the molasses, mix thoroughly with the sand, heat carefully at first to expel volatile matter. Place in a muffle and ignite at a low red heat.

(*c*) In a platinum ash dish heat 5 to 7 grams of the sample over a flame until intumescence ceases, then ignite in a muffle at low redness until the ash obtained is white, or nearly so.

(*d*) (Modification of the above method). Weigh a sample of the molasses, add a little pure olive oil (enough to form a thin layer), heat, and ignite as above. The oil serves to prevent excessive frothing; it must be free from non-volatile matter.

(*e*) If time permit, please determine ash also by methods (2) and (6), page 49, Bulletin 46, Division of Chemistry.

In each case after weighing the ash, heat again in the muffle for fifteen minutes and weigh. Repeat if the weight be not constant.

III.—*Determination of reducing sugars.*

(*a*) For the determination of reducing sugars follow the "gravimetric method" of the Association of Official Agricultural Chemists. (1 (*a*), page 51, Bulletin 46, Division of Chemistry.) Filter and wash the precipitated cuprous oxid in a Gooch crucible as directed under (*b*), page 56, Bulletin 46. Then determine the copper in nitric acid solution by the electrolytic method. (See (*d*), page 56.)

(*b*) In another sample determine the reduced copper by the "permanganate" method. (See (*e*), page 56.)

In each case state the weight of molasses employed, the weight of copper obtained, and the per cent of invert sugar.

IV.—*Determination of sucrose and raffinose.*

Dissolve 26.048 grams of the molasses in water, transfer to a 100 cc flask, add enough lead subacetate to clarify; throw down the excess of lead with sodium sulphate solution; render slightly acid with a few drops of dilute acetic acid. Then dilute to 100 cc, filter, and polarize in a 200 mm tube. Reading represents (P) in the formula.

By means of a pipette, transfer 50 cc of the filtrate to a 100 cc flask, add 20 cc distilled water, and 5 cc concentrated hydrochloric acid. (Should contain 38.8 per cent of HCl.) Mix by a circular movement of the flask. Place a thermometer in the flask, bulb of thermometer near the center of the bulb of the flask. Put the flask in a water bath and regulate the temperature so that the solution will reach 67° to 69° C. in five minutes. Maintain this temperature for exactly five minutes longer, keeping the heat as near 69° as possible. Remove the flask, cool contents quickly to 17.5°, and make up to 100 cc with water. Filter if necessary. Avoid the use of bone black if possible. Polarize the solution in a 200 mm "inversion" tube. Use an accurate thermometer. Make the invert reading at exactly 20° C. Invert reading multiplied by 2 equals (I) in the formula.

Calculate results according to Wortman's formulæ:

$$S=\frac{0.9598\ P-1.85\ I-0.277\ N}{1.5648}$$

$$R=\frac{P-S+0.3103\ N}{1.85}$$

In which—

P is polarization of normal solution before inversion.
I is invert reading multiplied by 2.
N is per cent reducing sugars.
S is per cent sucrose.
R is per cent raffinose.

The chemists of four experiment stations reported results. I am indebted to Prof. Elton Fulmer and to his assistant, Mr. W. H. Heileman, for a very complete report; to Messrs. Blouin, Winter, Kedzie, Miller, Munson, Chicquelin, Heuck, and Egge for their cooperation in this work, and to Prof. H. H. Nicholson and Dr. Wiley for valuable suggestions.

The results of the experimental work carried on this year, together with such deductions as the referee has been able to make, follow:

DETERMINATION OF WATER AND TOTAL SOLIDS.

The question of the best method of determining percentage of water in molasses and sugars is still a mooted one. It is certainly the most vexatious problem with which the sugar chemist has to deal. This association has considered the matter for a number of years, but as yet has come to no decisive conclusions.

Only two methods of desiccation were studied this year. One of these methods, the "Carr and Sanborn," has been adopted provisionally, but neither of them has received much attention from the association's chemists. The method of drying with quartz sand is one that is commonly employed in sugar-house laboratories, and has been found to yield good results so far as comparative work is concerned. The molasses experimented with this year contained such a high percentage of mineral matter and organic non-sugars that it was considered useless to try the method of dilution and "spindling."

The following results were reported:

Percentage of water by the Carr and Sanborn method.

Analyst.	Weight of dry matter obtained.	Water.	Average.
	Grams.	*Per cent.*	*Per cent.*
R. E. Blouin, La. Sugar Exp. Sta.	1.0008	23.88	23.66
	1.1534	23.45	
Geo. Chicquelin, La. Sugar Exp. Sta.	0.9990	23.57	23.45
	1.0300	23.34	
W. H. Heileman, Wash. Exp. Sta.	1.8313	24.12	24.15
	1.7672	24.05	
	1.9438	24.04	
	2.1800	24.01	
	2.2139	24.15	
	2.3841	24.17	
	2.2712	24.25	
	2.5299	24.29	
	2.6535	24.19	
R. S. Hiltner, Nebr. Exp. Sta.	1.3274	24.28	24.33
	1.3818	24.53	
	1.1811	24.31	
	1.0665	24.23	
H. K. Miller. N. C. Exp. Sta.	....	24.80	24.83
	....	24.96	
L. S. Munson, Mich. Exp. Sta.	1.5086	24.02	23.71
	2.2227	23.40	

Percentage of water.

[Desiccation with quartz sand.]

Analyst.	Weight of dry matter obtained.	Water.	Average.
	Grams.	*Per cent.*	*Per cent.*
R. E. Blouin, La. Sugar Exp. Sta.	2.2950	23.11	23.12
	2.2903	23.13	
Geo. Chicquelin, La. Sugar Exp. Sta.	2.3840	23.38	23.32
	2.8700	23.27	
O. H. Egge, Nebr. Exp. Sta.	1.9004	24.40	24.30
	2.9766	24.21	
W. H. Heileman, Wash. Exp. Sta.	1.5229	24.23	24.23
	0.7916	24.37	
	2.3570	24.18	
	2.3258	24.14	
R. S. Hiltner, Nebr. Exp. Sta.	3.1303	24.15	24.02
	3.1325	24.02	
	3.0947	24.13	
	3.3901	23.90	
	3.9714	24.03	
	3.8068	23.93	
H. K. Miller, N. C. Exp. Sta.	....	23.97	24.07
	....	24.18	
L. S. Munson, Mich. Exp. Sta.	2.9793	23.01	23.10
	2.9034	23.18	

Taken as a whole, these results are certainly encouraging, but unfortunately the number of determinations made is so small that no definite conclusions can be drawn.

By reference to the above tables, it may be seen that 14 of the 21 of the percentages, as given by the Carr and Sanborn method, are included between 24.53 per cent and 24.02 per cent, a difference of 0.51 per cent, or an average of 24.16 per cent. By the quartz-sand method, 14 of 22 results given lie between 24.40 per cent and 23.90 per cent, a difference of 0.50 per cent, or an average of 24.15 per cent. It may be safely concluded from this that if we desire simply a comparative method either one of these schemes may be used.

The time required for desiccation seems to bear no direct relation to the amount of material taken. It seems to depend rather upon the kind of apparatus used (ovens and capsules), to the proportion of pumice or sand used, and to details of manipulation. This is indicated in the following table:

Time required for desiccation.

Analyst.	Method.	Weight of sample.	Hours required for drying.	Ratio.
		Grams.		
W. H. Heileman, Wash. Exp. Sta.	Carr and Sanborn	2.5420 3.1806	10 12	1:3.9 1:3.8
L. S. Munson, Mich. Exp. Sta.	do	1.9856 2.9094	23 30	1:11.5 1:10.0
R. S. Hiltner, Nebr. Exp. Sta.	do	1.5496 2.1992	10 14	1:6.4 1:6.3
W. H. Heileman, Wash. Exp. Sta.	Quartz sand	2.0100 1.0467 3.0873	11 11 17	1:5.8 1:10.5 1:5.5
L. S. Munson, Mich. Exp. Sta.	do	3.8247	36	1:9.4
R. S. Hiltner, Nebr. Exp. Sta.	do	5.1160 4.1460	24 25	1:4.4 1:6.0

ASH DETERMINATIONS.

All of the official methods for ash determinations, except the method for soluble ash, were studied this year. The results are as follows:

METHOD A.—*Ignition with sulphuric acid.*

Analyst.	Weight of sample.	Ash (sulphate).	Average.	Ash ($\frac{1}{10}$ correction).	Average.
	Grams.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
R. E. Blouin, La. Sugar Exp. Sta.	5.2605 3.8385	8.58 8.54	8.56	7.72 7.69	7.70
Geo. Chicquelin, La. Sugar Exp. Sta.	3.7865 3.3000	8.54 8.53	8.53	7.69 7.68	7.68
W. H. Heileman, Wash. Exp. Sta.		8.30 7.83 7.94 8.02 8.10	8.04	7.47 7.05 7.15 7.22 7.29	7.24
R. S. Hiltner, Nebr. Exp. Sta.	5.2371 5.2973 6.5056 5.2898	8.23 8.62 8.44 8.65	8.48	7.41 7.76 7.60 7.79	7.64
C. H. Heuck, Nebr. Exp. Sta.	3.4691 4.5140 3.2983 4.4246	8.66 8.64 8.45 8.66	8.60	7.80 7.78 7.61 7.80	7.74
H. K. Miller, N. C. Exp. Sta.		8.74 8.74	8.74	7.87 7.87	7.87
L. S. Munson, Mich. Exp. Sta.		5.45	[1]5.45	4.91	[1]4.91
General averages			8.49		7.64

[1] Not included in the averages.

METHOD B.—*Alberti-Hempel.*

Analyst.	Weight of sample.	Ash.	Average.
	Grams.	*Per cent.*	*Per cent.*
R. E. Blouin, La. Sugar Exp. Sta	3.2795	5.32	5.24
	3.4431	5.16	
Geo. Chicquelin, La. Sugar Exp. Sta	3.1950	5.27	5.21
	2.9382	5.16	
W. H. Heileman, Wash. Exp. Sta	....	5.15	5.18
	....	4.76	
	....	5.09	
	....	5.09	
	....	5.43	
	....	5.37	
	....	5.35	
	....	5.25	
C. H. Heuck, Nebr. Exp. Sta	4.8957	4.96	5.16
	4.8949	5.37	
R. S. Hiltner, Nebr. Exp. Sta	4.1272	5.19	5.17
	4.1227	4.94	
	4.0791	5.20	
	4.4552	5.14	
	5.2275	5.28	
	5.0046	5.30	
H. K. Miller, N. C. Exp. Sta	....	5.69	[1]5.52
	....	5.20	
	....	5.50	
	....	5.72	
L. S. Munson, Mich. Exp. Sta	....	5.15	5.15

[1] Omitted from average.

METHODS C AND D.—*Direct ignition.*

Analyst.	Ash. (Incineration without oil).	Average.	Ash. (Incineration with oil).	Average.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Geo. Chicquelin, La. Sugar Exp. Sta	7.05	7.05	....	....
	7.05		....	
W. H. Heileman, Wash. Exp. Sta	6.93	6.97	7.05	7.10
	6.97		7.15	
	7.03		....	
	6.91		....	
	6.99		....	
R. S. Hiltner, Nebr. Exp. Sta	6.92	6.89	6.72	6.92
	6.57		7.05	
	6.93		7.01	
	7.15		....	
H. K. Miller, N. C. Exp. Sta	7.18	7.08	....	....
	6.98		....	
L. S. Munson, Mich. Exp. Sta	6.54	6.54	....	....

METHOD E.—*Ignition with zinc oxid.*

Analyst.	Ash.	Average.
	Per cent.	*Per cent.*
W. H. Heileman, Wash. Exp. Sta	7.49 7.27	7.38
R. S. Hiltner, Nebr. Exp. Sta	6.68 6.71	6.69
General average	....	7.03

METHOD F.—*Ignition with benzoic acid.*

Analyst.	Ash.	Average.
	Per cent.	*Per cent.*
W. H. Heileman, Wash. Exp. Sta	6.90 6.88 [1]6.65 6.78	6.85
R. S. Hiltner, Nebr. Exp. Sta	6.80 7.14 [1]6.31 [1]6.54	6.97
General average	....	6.91

[1] Ash fused; not included in average.

Summary of results.

Method.	Average per cent of ash.
Ignition with sulphuric acid	7.64
Ignition with quartz sand	5.18
Direct ignition	6.90
Direct ignition (oil added)	7.01
Ignition with zinc oxid	7.03
Ignition with benzoic acid	6.91

By the same methods the results of these determinations of ash in beet molasses compare in a general way with the results of analyses of cane products which were carried on a few years ago by the association's chemists. (See Bulletin 38, p. 150.) This would indicate that for ash no special method nor modifications of present methods are necessary for beet products.

The percentage of "sulphated" ash is, as usual, too high as compared with that obtained by other methods, signifying that the one-tenth correction proposed by Scheibler is too small. In spite of this fact I take it that the association would still be unwilling to drop this process from the list of official methods or to consider a change of factor. This method may always be relied upon to yield concordant results. Incineration in the presence of sulphuric acid is readily effected and the resulting ash is but little changed by high temperatures. Moreover, "sulphated" ash is usually employed in calculating rendement, another argument in favor of retaining the method.

The most uniform results were obtained by ignition with sand. As may be seen from the above table, this method yields a much lower percentage of ash than any other of the methods tried. The reason for this is understood to be that the organic acids are replaced by silicic acids, leaving little or no carbonates; the salts of the inorganic acids, with the exception of nitrates, remain unchanged.

The results obtained by the direct ignition of the molasses and by ignition with benzoic acid agreed more closely than was anticipated. The difficulty usually experienced is in controlling the temperature of the muffle to prevent loss of salts by volatilization. By a few experiments the referee has attempted to show the effect of high temperatures upon the ash of the molasses in question.

Temperature.	Sulphate method.	Alberti-Hempel method.	Direct ignition.	Ignition with oil.	Ignition with benzoic acid.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Very low red heat till completely ashed	7.76	5.20	6.93	6.72	6.80
Bright red heat for fifteen minutes	7.75	5.06	6.73	6.38	6.36

The addition of a small amount of olive oil to the sample before incineration is a convenience, simply preventing excessive foaming. As to the value of the methods of ashing with benzoic acid and with zinc oxid no conclusions can be drawn from the present series of experiments.

REDUCING SUGARS.

In commercial and factory control the amount of reducing sugars in beet products is regarded as nil and is almost never determined. The results obtained, however, show the presence of these sugars in small quantities and also show the value of the gravimetric methods, so called, for the exact determination of them. In fact the volumetric methods, such as Soxhlet's modified method, may not be used, owing to the large proportion of sucrose.

The process of estimating the amount of reduced copper by titrating with permanganate solution is simple and rapid and yields results that agree closely with those by the electrolytic method.

The results obtained by almost all of the analysts by both methods agree very closely. These results are presented in the following table:

METHOD A.—*Reduced copper determined by electrolysis.*

Analyst.	Weight of sample used.	Weight of copper.	Reducing sugars calculated as dextrose.	Average.
	Grams.	*Gram.*	*Per cent.*	*Per cent.*
R. E. Blouin, La. Sugar Exp. Sta	10	0.0380	0.199	0.199
W. H. Heileman, Wash. Exp. Sta	10	.0405	.211	.196
	10	.0330	.175	
	10	.0375	.196	
	10	.0345	.183	
	10	.0425	.221	
C. H. Henck, Nebr. Exp. Sta	10	.0536	.277	.277
R. S. Hiltner, Nebr. Exp. Sta	6.500	.0371	.298	.298
H. K. Miller, N. C. Exp. Sta			.120	.120
L. S. Munson, Mich. Exp. Sta	15.7544	.002	.202	.199
	17.1460	.0654	.196	

METHOD B.—*Reduced copper determined by titration with permanganate solution.*

Analyst.	Weight of sample used.	Copper equivalent.	Reducing sugar.	Average.
	Grams.	*Gram.*	*Per cent.*	*Per cent.*
W. H. Heileman, Wash. Exp. Sta.	10	0.0383	0.200	0.196
	10	.0379	.199	
	10	.0375	.196	
	10	.0363	.190	
R. S. Hiltner, Nebr. Exp. Sta.	7.9962	.0390	.300	.305
	16.1967	.0990	.311	

DETERMINATIONS OF SUCROSE AND RAFFINOSE.

There certainly can be no doubt as to the presence of raffinose in some of the by-products of American beet-sugar houses. (See Journ. of Am. Chem. Soc., 1897.) Moreover, there can be no doubt as to the presence of small amounts of reducing sugars in low-grade factory products, even when obtained under normal conditions.

It is common practice in cane-sugar houses to determine sucrose by double polarization, using for calculations Clerget's formula. This gives correct values when sucrose and invert sugar are alone present. When, however, sucrose is associated with raffinose and when, as is commonly the case with beet products, invert sugar is absent, the following formulæ proposed by Creydt are employed:

$$S=\frac{0.5188\ P-I}{0.845}\qquad R=\frac{P-S}{1.85}$$

Beet-sugar chemists, both in this country and in Europe, usually employ Clerget's formula when raffinose is absent, and the Creydt formula when this sugar is present. In each case the presence and influence of any reducing sugar is ignored.

The referee's purpose in asking for the estimation of sucrose and raffinose in the samples distributed was to determine the practicability of existing methods when applied to such material, and also to find out if possible the effect of a small amount of reducing sugars upon the double polarization. The extent of error, if any, that results from disregarding the influence of the reducing sugars should appear by calculating the percentages of sucrose and raffinose by Wortman's and by Creydt's formulæ. The results as reported follow:

Analyst.	Normal polarization before inversion.	Normal polarization after inversion.	Reducing sugar (dextrose).	Sucrose (Wortman).	Raffinose (Wortman).	Sucrose (Creydt).	Raffinose (Creydt).
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
R. E. Blouin	57.35	14.6	0.199	52.40	2.70	52.48	2.63
Geo. Chicquelin	57.1	14 4	.215	52.02	2.78	52.09	2.70
W. H. Heileman	56 58	16.1	.196	53.70	1.59	53.79	1.50
C. H. Heuck	57.0	13.6	.277	51.64	2 94	51.09	3.19
R. S. Hiltner	56.9	14.0	.300	51.30	3.07	51.50	2.91
H. K. Miller	....	....	.120	49.50	4.40	....	....
L. S. Munson	56.0	12 4	.199	48.97	3.84	49.05	3.75

The exact significance of such a variety of results is not clear. On the whole, the direct polariscopic readings as reported agree fairly well, but the differences in polarization after inversion are large and at the same time difficult to explain.

The molasses in question was an extremely difficult substance to clarify, making optical determinations of the sugars not at all easy. This fact would doubtless justify a certain slight variation in polarimetric tests, but such a wide variety of polariscopic readings as given above can not be explained nor justified in this way. The referee's observations in experimenting with this molasses were that a wide range of results could be obtained by changing slightly the time and temperature conditions of the method of inversion, but by following out one particular scheme in detail concordant results would in each case follow. Other analysts have probably experienced the same thing, a fact which points to the necessity of further investigation of this subject.

Besides studying details of a method for double polarization, it would be well for the association to consider what formulæ for calculation shall be used for various sugar-house products. One thing is certain, we may not properly apply the same formulæ to both cane and beet products. The presence of raffinose in the latter often precludes the use of Clerget's formula. It would be rash to decide upon these points from the limited data herein reported. We must as an association either investigate the question for ourselves or else decide from the experiments of individual investigators. From the results given in the last table, it would seem unnecessary to employ Wortman's formula for calculating sucrose and raffinose, the percentage of reducing sugars being too small to be of any serious consequence.

The referee would ask that the following recommendations be considered:

(1) That the Carr & Sanborn method for determination of water in molasses, etc., be adopted as an official method.

(2) That the method of desiccation with quartz sand be made an optional or a provisional method, and that the association experiment further with it.

(3) That to the method for determining per cent of water from the density a note be added to the effect that this method does not apply to low grade sugar products.

(4) M. Lucien, in describing his method for ash by incineration with zinc oxid, proposes to use 0.050 gram zinc oxid with 5 grams sugar or with 3 grams molasses. (Bul. de l'Assoc. des Chem., vol. 6, p. 356.) On the other hand, our official method calls for the same amount of zinc oxid, 0.050 grams, with 50 grams sugar or 25 grams molasses. I do not understand the reason for this discrepancy. My own experience has been that the proportion of zinc oxid, as suggested in our official method, is entirely too small. It is probable that the difference is due to a typographical error in our method, and if so, it should, of course, be corrected. If we divide by 10 the weight of sample to be employed, we will approximate the proprotions of sugar to zinc oxid proposed by Lucien.

(5) That methods (b) and (c) for determination of copper in the cuprous oxid obtained in determining reducing sugars be dropped from the list of official methods. This will leave us one electrolytic method, the Formanek, which is conceded to be the simplest and most rapid of the three.

(6) That in the text of method (e) for determination of reduced copper, directions be inserted for preparing the permanganate solution used. The number of grams of potassium permanganate required per liter should be stated. (Sol.=4.976 3 grams per liter.)

(7) That Creydt's method (Zeit Rübenzack, Ind. 38, 867) for determination of sucrose and raffinose be adopted provisionally and added to the list of "methods by inversion."

In the discussion of this paper Mr. Bigelow called attention to the fact that in the volumetric method depending upon the use of a permanganate solution and ferrous salt, the permanganate should be carefully compared with the ferrous sulphate.

After further discussion of the paper, the president recognized Mr. Jaffa, for the purpose of extending his invitation to the association to hold its next meeting in San Francisco. Mr. Jaffa assured the association of the hospitable welcome which it would receive upon the Pacific coast, and spoke of the advantages of meeting now and then in other localities than Washington. The members would find upon the Pacific coast conditions prevailing which are entirely different from those upon the Atlantic side of our country, and they would not only have great pleasure but also profit from personal inspection of the methods of work in vogue beyond the Rocky Mountains. Among other things, he said the members would be delighted to meet Professor Hilgard, the state of whose health prevented him from attending the meetings at such a distance.

Responding to questions in regard to the rates, Mr. Jaffa said that while he could not say what they would be he could say they would be about the smallest that had ever been inaugurated. A great many associations had already decided to meet on the Pacific coast during the summer and autumn of 1899, and the rates which could be had for the large associations would apply also to the small ones.

The association was much impressed with Mr. Jaffa's presentation of the advantages which would come to it by holding a session on the Pacific, and it was voted that the matter be left to the executive committee, with power to act.

DELEGATES TO NATIONAL PURE FOOD AND DRUG CONGRESS.

At the conclusion of Mr. Jaffa's address the secretary called attention to a communication from Mr. A. J. Wedderburn, corresponding secretary of the National Pure Food and Drug Congress, stating that the second annual session of this congress would convene in Washington on the 18th of January, and the association was requested to name five delegates and five alternates to represent it in the congress. Attention was also called to the fact that each official agricultural chemist of the country, by virtue of his office, was entitled to membership in the congress and was heartily invited to be present.

The president appointed the following delegates: H. W. Wiley, A. L. Winton, W. D. Bigelow, H. J. Wheeler, L. L. Van Slyke, and E. A. de Schweinitz. Alternates: W. O. Atwater, A. B. Peebles, H. B. McDonnell, H. E. Alvord, H. J. Patterson, and R. A. Emerson.

On the suggestion of Mr. Wheeler it was voted that the secretary of the association be requested to rewrite the methods of analysis preparatory to having them reprinted, with the object of condensing them so far as would be possible without sacrificing clearness. It was also voted that he be allowed to select as many assistants in the conduct of this work as might be necessary to secure its prompt completion.

It was suggested by Mr. C. B. Coates that the agricultural colleges and experiment stations should pay the expenses of the delegates to attend the meetings of the association. This opinion was heartily indorsed by other members of the association, with expressions of a belief that the portion of the money used for experimental work could not be better applied than by sending the workers to these conventions, where they would meet those engaged in similar work, compare notes, make acquaintances, and, in general, fit themselves all the better for the proper conduct of their work.

At 3.15 it was voted to adjourn, as it seemed to be impossible, even with the strict attention to business which had been indulged in, to finish the business of the association before Monday.

THIRD DAY.

MONDAY—MORNING SESSION

The association reconvened at half-past nine.

The president congratulated the members on having present the honorable the Secretary of Agriculture. A few years ago, many might remember, when the experiment stations were in their infancy, the meetings of this association were not regarded with any favor and they were not patronized by the distinguished gentlemen at the head of affairs. This state of things has largely passed away, and now our association is honored annually by the presence of a Cabinet officer for the purpose of expressing his interest in our work and giving us words of encouragement. The presence of the Secretary of Agriculture is an evidence that the spirit of research and discovery is triumphant throughout the whole area where scientific agriculture is practiced and promoted by the United States Government. A part of the power which the experiment stations have acquired is shown in the fact that the President of the United States selected the director of an agricultural experiment station for the responsible position of Secretary of Agriculture. This is a matter of which we should all be proud, and for this especial reason, as well as for many others, we are glad to have with us this morning the Secretary of Agriculture.

The Secretary then addressed the Association.

REMARKS OF SECRETARY WILSON.

The Secretary commenced his address by recalling the visit of Dr. Armstrong, a distinguished English chemist, who came to Washington expecting to spend a half day in looking over the scientific divisions of the Department of Agriculture. After having been here a week he expressed the belief that he could not even begin to comprehend the great scientific work which the Department was doing if he should stay a month.

The Secretary, continuing, said:

I lately asked Dr. Wiley for the reason why we imported so many chemicals. I noted down some of the points which he mentioned and will refer to them further on.

Very little progress could be made in any vocation of life without the help of the chemist. He is indispensable to the farmer. The composition of soils and their supply of plant food are the first lesson the producer should learn. Where fertilization is necessary and the market must be sought, the chemist is the only protector the purchaser can rely on. The feeder nowadays finds it necessary to know the composition of every nutrient, adapt it to the age of the animal and the purpose he has in view. The ration that will fatten the steer will put the cow dry, or what is suitable for the yearling is wasted on the mature animal. Plants vary in protein, from young clover to old timothy. The growing colt needs the composition of the former in his ration, the idle horse does well on the latter. Between the nutritive ratios of the two plants is latitude sufficient to waste the profits of labor. Farming is not profitable until we learn to feed, and our first teacher is the chemist.

We should know how to feed ourselves and others. People tell us of the sufferings of those who have only army hard-tack to eat, not having learned that, after milk, it comes nearest being complete food. Southern workmen had corn bread, fat pork, and molasses until the chemist told them to grow beans, keep cows, and balance their rations.

The markets abound with mill feeds that vary in composition as much as oil meal and wheat straw. We look to the report of the chemist to direct us in buying. It is settled that we must teach chemistry to mothers and cooks, so that they will know how to vary the rations for a child, a youth, a laboring man, and an octogenarian.

The chemist has analyzed sugar beets for us grown in most of the States, and tells us where conditions are suitable for the investment of $200,000,000 of capital, now lying idle or being loaned in Europe, to build factories where 1,800,000 tons of sugar may be made and save $100,000,000 to the United States and give good wages to hundreds of thousands of workmen.

We paid $41,470,711 for chemicals, drugs, and dyes the last fiscal year; five-eighths of these came in free; three-eighths paid duty. Somebody blundered. We have educated chemists, capital and raw material in great abundance, and should provide these things for ourselves, as we make steel and tin. An extensive island area is being added to our domain, where the scientist has made little research. The chemist should go with the botanist, the pathologist, and the roadmaker. We must learn of the soils, their origin and composition, before we can tell what they can permanently and profitably produce.

The Secretary's address was greeted with hearty applause.

At its conclusion the president called for the report of the referee on tannin. The referee, Mr. J. H. Yocum, read the following report:

REPORT ON TANNINS.

J. H. Yocum, *Referee.*

The comparative work on tannins during the past year is of considerable interest, inasmuch as there are no less than twenty individuals contributing, and in addition to the results obtained on the samples sent out, Messrs. Carr, Forbes, Eachus, and Alsop present some interesting data relative to the method, which are embodied in this report.

Two lots of samples were sent out, the first at the beginning of the year being a commercial chestnut-wood extract and a hemlock liquor, and with these were sent two makes of hide powder, one from Vienna and the other from Ridgway, Pa.

It was requested that the official method be followed, and that if other than the official method were in use by the collaborator results by it be also sent in. The hemlock liquor was thoroughly filtered before being sent out, and showed no precipitate at 40° F. and contained no reds at the time of shipment.

The second lot of samples was an extract made by the referee from grape sugar and gallotannin and contained no precipitate when shipped, but upon standing some three months did precipitate some insoluble material. The reports, however, were all in before this was noticed, and it is not probable that there was any insoluble material in this extract when the various analyses were made. Vienna hide powder was sent with this sample.

The results obtained are as follows:

Chestnut-wood extract.

Name.	Hide.[1]	Moisture.	Total solids.	Soluble solids.	Non-tannins.	Tannins.	Reds.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Pr ct.*
Allaire	A	59.59	40.41	38.45	14.05	24.40	1.96
	B	....	....	....	14.34	24.11	
Alsop	A	59.17	40.56	37.99	13.75	24.24	2.57
	B	....	....	....	13.69	24.30	
Carr	A	50.49	40.53	37.66	15.53	22.13	2.87
	B	....	....	....	15.72	21.94	
Eachus	A	59.17	41.06	39.14	14.21	24.93	1.92
	B	....	....	....	14.36	24.78	
Eitner (Weiss)	A	58.16	41.84	40.89	14.45	26.14	.95
	B	....	....	....	14.55	26.34	
Forbes	A	58.22	41.48	40.12	13.92	26.20	1.36
	B	....	....	40.09	13.86	26.23	1.39
Haley	A	58.96	41.04	38.62	13.88	24.74	2.42
	B	....	....	....	14.06	24.56	
Hurty	A	58.11	41.89	39.38	14.87	24.51	2.51
	B	....	....	....	14.80	24.58	
Krug	A	59.60	41.05	39.54	14.16	25.38	1.51
	B	....	....	....	14.78	24.76	
Lowell	A	58.15	41.85	39.50	14.65	24.85	2.35
	B	....	....	....	14.75	24.75	
McDowell	A	58.95	40.87	38.70	14.03	24.67	2.17
	B	....	....	....	14.64	24.06	
Proctor	A	58.97	41.03	38.10	15.55	22.55	2.93
	B	....	....	....	15.30	22.80	
Small	A	59.21	40.72	38.22	14.57	23.65	2.50
	B	....	....	....	14.22	24.00	
Tiffany	A	58.89	41.11	38.97	13.46	25.51	2.14
	B	....	....	....	13.69	25.28	
Westenfelder[2]	......	59.05	41.44	38.06	14.33	24.63	2.99
Parker[2]	A	....	....	40.10	12.20	27.90	
	B	....	....	....	14.30	25.80	
Touse[2]	A	....	....	40.16	12.25	27.91	
	B	....	....	....	14.50	25.66	
Yocum	A	59.20	40.59	38.20	13.61	24.59	2.39
	B	....	....	....	13.92	24.28	
Mean	A	58.89	41.07	38.98	14.31	24.67	2.09
Maximum	A	59.60	41.89	40.89	15.55	26.44	2.93
Minimum	A	58.11	40.41	37.66	13.46	22.13	.95
Mean	B	....	....	....	14.52	24.46	
Maximum	B	....	....	....	15.72	26.34	
Minimun	B	....	....	....	13.69	21.94	
Maximum difference from minimum	A	1.49	1.48	3.23	2.09	4.31	1.98
	B	....	....	....	2.03	4.40	
Maximum difference from mean	A	.71	.82	1.91	1.24	2.54	1.14
	B	....	....	....	1.20	2.52	

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[1] Hide powder "A" was the Vienna product; hide powder "B" was the Ridgway product.

[2] Not having followed official method, are not included in average.

Hemlock liquor.

Name.	Hide.[1]	Total solids.	Soluble solids.	Non-tannins.	Tannins.	Reds.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per ct.*
Allaire	A	4.57	4.44	2.02	2.42	0.13
	B	....	....	2.10	2.34	....
Alsop	A	4.72	4.57	2.20	2.36	.15
	B	....	....	2.12	2.45	....
Carr	A	4.63	[2]4.63	2.32	2.31	....
	B	....	....	2.35	2.28	....
Eachus	A	4.78	4.68	2.13	2.55	.10
	B	....	....	2.22	2.44	....
Eitner (Weiss)	A	4.77	4.63	2.16	2.47	.14
	B	....	....	2.18	2.45	....
Forbes	A	4.69	4.67	2.14	2.53	.02
	B	....	....	2.18	2.49	....
Haley	A	4.83	4.63	2.35	2.28	.20
	B	....	....	2.17	2.46	....
Krug	A	4.54	4.48	2.16	2.32	.06
	B	....	....	2.13	2.35	....
Lowell	A	4.84	4.74	2.20	2.54	.10
	B	....	....	2.24	2.50	....
McDowell	A	4.74	4.63	2.18	2.45	.11
	B	....	....	2.23	2.40	....
Proctor	A	4.72	4.53	2.25	2.28	.19
	B	....	....	2.24	2.29	....
Small	A	4.64	4.55	2.16	2.39	.09
	B	....	....	2.17	2.38	....
Yocum	A	4.71	4.66	2.14	2.52	.05
	B	....	....	2.13	2.53	....
Parker	A	4.80	[2]4.80	2.00	2.80	....
	B	....	....	2.20	2.60	....
Mean	A	4.71	4.60	2.17	2.43	.11
Maximum	A	4.84	4.74	2.35	2.55	.19
Minimum	A	4.54	4.44	2.00	2.28	.02
Mean	B	....	....	2.19	2.41	....
Maximum	B	....	....	2.35	2.53	....
Minimum	B	....	....	2.10	2.28	....
Maximum difference from mean	A	.17	.16	.18	.15	.09
	B	....	....	.16	.13	....

[1] Hide powder "A" was the Vienna product; hide powder "B" was the Ridgway product.

[2] Not filtered for soluble solids and hence not included in averages of soluble solids and tannins.

Theoretical extract.

Name.	Moisture.	Total solids.	Soluble solids.	Non-tannins.	Tannins.	Reds.	Red tannin.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per ct.*	*Per cent.*
Alsop	61.20	38.82	37.32	19.18	18.14	1.50	19.64
Carr	61.97	37.91	[1]37.91	18.66	19.25	....	19.25
Eachus	61.60	38.43	37.42	18.00	18.52	1.01	19.53
Forbes	60.57	39.43	[1]39.43	19.04	20.39	....	20.39
Haley	60.69	39.23	37.46	18.64	18.82	1.77	20.59
Hurty	60.73	39.27	38.33	18.89	19.44	.94	20.38
Kerr	60.01	39.99	38.33	21.41	16.92	1.66	18.58

[1] Not filtered for soluble solids, hence not included in averages of soluble solids or tannins.

NOTE.—Hide powder was the Vienna product.

Theoretical extract—Continued.

Name.	Moisture.	Total solids.	Soluble solids.	Non-tannins.	Tannins.	Reds.	Red tannin.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per ct.*	*Per cent.*
McDowell	60.94	38.72	37.50	19.12	18.38	1.22	19.60
Nichols	61.35	38.65	36.88	18.68	18.20	1.77	19.97
Small	61.99	38.09	36.95	17.50	19.45	1.14	20.59
Yocum	61.05	38.20	36.80	17.90	18.90	1.40	20.30
Mean	61.10	38.79	37.44	18.90	18.54	1.35	19.89
Maximum	61.99	39.99	38.33	21.41	20.39	1.77	20.59
Minimum	60.01	37.91	36.80	17.50	16.92	.94	18.58
Maximum difference from minimum	1.98	2.08	1.53	3.91	3.47	.83	2.01
Maximum difference from minimum	1.09	1.20	.89	2.51	1.85	.42	1.31
Theoretical content of sample	62.23	37.77	37.77	17.58	20.19	....	20.19

Mr. Pierre Allaire states that the official method was followed; that he considers hide powder "A" a little better than "B," and that he did not obtain a perfectly clear non-tannin filtrate from the extract. Mr. B. Weiss made the analysis of the sample sent to Mr. Eitner of the Vienna Research College for the Leather Industries. He states that he pursued the official method, and also reports his results from the filter-tube method. He obtained 13.90 per cent non-tannins on the chestnut-wood extract and 2.13 per cent non-tannins on the hemlock liquor by following the filter-tube method.

Dr. Hurty obtained 41 per cent total solids, 39.68 per cent soluble solids, 15.50 per cent non-tannins, and 24 18 per cent tannins by a method he published sometime ago in the Leather Manufacturer.

W. C. Tiffany: "Our method varies from the official in that we employ 10 instead of 15 grams dry hide powder, and we shake three times, using one-third of the hide powder each time." He reports from this method 41.11 per cent total solids and soluble solids—non-tannins from "A" hide powder, 12.32; "B," 12.90—giving respectively, 28.79 per cent and 28.21 per cent tannins.

Mr. Kerr states that the sample of grape sugar and gallotannin was clear and light brown in color when received, but before being analyzed was covered with a luxuriant growth of mold. He doubts the value of his results in consequence.

M. S. McDowell: "The extract (grape sugar and gallotannin) when dissolved made a clear solution, but upon filtering through S. & S. paper 1.22 per cent were removed. Am of the opinion that in all cases there is an absorption, greater or less, by the cellulose of the filter paper."

Mr. Lowell reports on the chestnut-wood extract 15 per cent non-tannins and on the hemlock liquor 2.23 per cent non-tannins by following the official method and using the kind of hide powder employed in his laboratory, which contained 0.0070 gram of material soluble in water, as per directions for obtaining same.

Mr. Kerr states that by using his laboratory hide powder, which contained 0.0080 gram soluble material, he obtained 21.41 per cent non-tannins from the grape-sugar extract.

Dr. J. Gordon Parker reports results obtained by Herolds Institute method: tannins 28.90 per cent, non-tannins 12.10 per cent, solids 40.10 per cent on the chestnut-wood extract; and tannins 2.80 per cent, non-tannins 2 per cent, solids 4.80 per cent on the hemlock liquor. He states: "You will notice that they (the analyses he reports) are all done by the hide-filter method. * * * None of the hide powders has been washed, as you instructed, an ordinary analysis being made according to the method laid down by the international association with Proctor's form of hide filter, 5 grams of powder being used in each case. Mr. Touse, my colleague, employed the same process."

Dr. H. R. Proctor: "The method appears to be a good one, and the two hide powders give very concordant results; but I do not know that it is better than the 'International,' while the results are in every case lower. I do not regard this as a defect, though it is impossible with our present knowledge to say that either give the absolute percentage of tanning, or one more than the other."

By the "International" filter-tube method he obtains on the chestnut-wood extract: tanning matter 27.9 per cent, non-tannins 11.8 per cent, insoluble at 60° F. 1.9 per cent, water 58.4 per cent. By the Yorkshire College shake method: tanning matter, Vienna hide 24.1 per cent, Buffalo hide 22.4 per cent; non-tannins, Vienna hide 15.6 per cent, Buffalo hide 17.3 per cent. In this last method the powder is added in three successive portions, 6 grams powder used and 100 cc of liquor. The Buffalo powder is coarse-ground dry hide, heavy, granular, and unsuitable for the filter tube. In the filter method the first 30 cc passing through are thrown away, the next 50 cc evaporated for non-tannins. On the hemlock liquor, by the "International" method, Dr. Proctor obtained tanning matter 2.45 per cent, non-tannins 2.16 per cent; and by the Yorkshire method, tanning matter 2.25 per cent, non-tannins 2.35 per cent, results being identical from both Vienna and Buffalo hide.

Dr. Forbes reports non-tannins obtained by the use of Fiebing's hide powder in the chestnut-wood extract 13.15 per cent; in the hemlock liquor 2.05 per cent, and in the grape-sugar extract 19.05 per cent. All filtrations were done through No. 597 S. & S. paper, and all dryings at 100° C.

E. J. Haley finds 14.28 per cent non-tannins in the chestnut-wood extract from a hide powder of his own make. He reports the ash analysis of the two hide powders sent out:

	"A" hide.	"B" hide.
	Per cent.	*Per cent.*
Ash	0.19	0.36
Lime	.06	.05
Alumina	Trace.	Trace.
Ferric oxid	Trace.	Trace.

Mr. F. H. Small reports that his laboratory method does not vary from the official to any extent and hence does not report from it.

Mr B. D. Westenfelder: "I did not follow directions you sent out, but used my laboratory method. It is as follows: Dissolve in water at 40° C. in a 500 cc flask; place on water bath for fifteen minutes and agitate frequently; fill to mark with cold water; cool rapidly in cold water and make up to 1 liter; filter through 20 cm double-folded S. & S. No. 6298 filter paper; discard first 100 cc that passes through; refilter then till absolutely clear.

Wash hide powder with water containing acid sodium sulphite and sulphuric acid, then wash till absolutely free from soluble hide and saline matter, squeeze and shake. All residues dried in air oven at 104° to 106° C. for two hours." His results are:

	Chestnut-wood extract.	Hemlock liquor.	Grape-sugar extract.
	Per cent.	*Per cent.*	*Per cent.*
Solids	41.95	4.57	39.80
Soluble solids	38.96	4.57	39.80
Non-tannins:			
No. 1	13.07	2.13	19.53
No. 2	14.33	2.13	19.83

Non-tannin No. 1 wet hide powder was added, in two portions of 25 grams each; 50 grams wet hide total used. Non-tannin No. 2, 50 grams wet hide added at once, 200 cc of liquor used for shaking and 100 cc evaporated; wet hide powder contained 78 per cent moisture. In the case of the liquor only 40 grams of wet hide were used.

Mr. Oma Carr states that at 25° C. he obtained 2.09 per cent of reds in the chestnut-wood extract, and at 10° C. 3.66 per cent reds, an increase of 1.57 per cent. He also states that at 25° C. the hemlock liquor was clear, but at 10° C. he found 0.[illegible]0 per cent of reds. By dissolving an extract according to the method (20 grams to the liter), and by dissolving it so that it will make a liquor of 1.02 sp. gr., he finds:

	Official.	At 1.02 sp. gr.	Difference.
	Per cent.	*Per cent.*	*Per cent.*
Total solids	40.63	40.43	0.10
Soluble solids	37.66	37.38	.28
Reds	2.87	3.05	.18
Tannin	22.03	21.71	.32
Non-tannins	15.63	15.66	.03

This liquor of 1.02 sp. gr. gave soluble solids, at 25° C. 37.38, and at 8° C. 35.94, a difference of 1.44. Mr. Carr presents the following data regarding the drying of the grape-sugar extract:

Dried in air at 100° C.

Solids (direct).			Solids (indirect).			Non-tannins.		Tannins.	
Time.	Interval.	Per cent.	Time.	Interval.	Per cent.	Time.	Interval.	Per cent.	Per cent.
2	......	40.46	3	......	39.26	......	......	......	......
4	2	40.00	......	......	......	......	......	......	......
10	6	39.04	......	......	......	......	......	......	......
12	2	38.99	......	......	......	16	......	19.67	......
28	16	38.48	24	21	38.28	24	8	19.46	18.82
32	4	38.35	......	......	......	......	......	......	......
50	18	38.03	42	18	37.91	45	21	18.66	19.25
56	6	37.93	50	12	37.81	64	19	18.10	19.71
96	40	37.51	90	40	37.22	112	48	17.22	20.00
136	40	37.29	138	48	36.99	136	24	16.92	20.07
Theoretical contents of sample	......	......	......	......	37.77	......	......	17.58	20.19
Maximum decrease		3.17	......	......	2.27	......	......	2.75	......

"The non-tannins show a rate of decomposition about twice as great as the solids as a whole—precisely as it should be, considering that the non-tannins are largely left-handed sugars.

"The absurdity of drying five days without constant weight is manifest. In my opinion, the water is wholly expelled from residues of 500 milligrams or less inside of four hours and any loss thereafter is chargeable to decomposition. These sugars of the dextrose order do not oxidize appreciably, while their rate of decomposition is wholly dependent upon the temperature used in their dehydration. It is possible to select from the above table percentages in fair accordance, but I hold that such arbitrary selection is absolutely without apology where the rate of decrease continues thereafter, whether more slowly or not.

"It seems to me wisely consistent with the best interest of the method to stipulate that extracts and other materials containing large quantities of invert sugars must be dried in vacuo at 70° C. The theoretical sample has served the exceedingly useful purpose of proving the inapplicability of ordinary dehydration methods to its desiccation. If the objection be made that chemists are not supplied with means of vacuum drying, it is a wholly consistent thing to require them to provide it. In the analysis of sugar, ore, milk, etc., the means have been adapted to the method, and the polariscope, assay balance, and Babcock machine are essentials.

"When it comes thus to a choice between a method vitally defective and one in which special apparatus must be provided, which is necessary in the operation of a method which has the advantage of accuracy, there seems hardly room for debate."

Mr. Eachus presents the following data on drying:

"Twelve portions of 100 cc of well-mixed extract solution (20 grams to the 100 cc) were evaporated to dryness. Six of these were dried on the top shelf of a hot-air oven; the other six were dried on the bottom shelf of the same oven. At the end of three hours one dish from each shelf was weighed, and at one hour intervals thereafter a dish was weighed from each shelf. The temperature of the top shelf was 100° C, and of the bottom shelf 125° C.

"Twelve portions of 100 cc of non-tannins from the same solution were treated similarly.

Time.	Solids.			Non-tannins.		
	100° C., top shelf.	125° C., bottom shelf.	Difference.	100° C., top.	125° C., bottom.	Difference.
	Gram.	*Gram.*	*Gram.*	*Gram.*	*Gram.*	*Gram.*
After 3 hours	0.8399	0.8218	0.0181	0.3036	0.2843	0.0193
After 4 hours	.8275	.8152	.0123	.3052	.2842	.0210
After 5 hours	.8280	.8111	.0169	.3051	.2855	.0196
After 6 hours	.8247	.8099	.0148	.3044	.2842	.0202
After 7 hours	.8244	.8009	.0235	.3027	.2820	.0207
After 8 hours	.8283	.8027	.0256	.3072	.2863	.0209
Average			.0185			.0203

"From this it is seen that variations are due to drying at various temperatures and that a constant weight is obtained by drying at 100° C. for from four to eight hours, but that a loss of non-tannins occurs by drying at 125° C. both in the total solids and non-tannin determinations, probably due to decomposition of the non-tannins. Variations in temperature within these limits affect the non-tannins largely without any considerable action upon the tannins. Variations then in drying tannin solutions are a function of the temperature, although no doubt long-continued drying at 100° C. would occasion oxidation of the tannin.

"Fourteen analyses of an extract were made and the drying done in various ways, always making it a point to dry the soluble solids and non-tannins under identical conditions and side by side in the drying oven.

Dried on—	Weight of soluble solids.	Weight of non-tannins.	Soluble solids.	Non-tannins.	Tannins.
	Gram.	*Gram.*	*Per cent.*	*Per cent.*	*Per cent.*
Top shelf hot-air oven, 4 hours at 100° C	0.8686	0.4426	43.43	26.12	17.31
Top shelf hot-air oven, 8 hours at 100° C	.8657	.4400	43.29	25.96	17.33
Bottom shelf hot-air oven, 4 hours at 125° C	.8306	.4131	41.53	24.37	17.16
Bottom shelf hot-air oven, 8 hours at 125° C	.8366	.4117	41.83	24.29	17.54
Top shelf water oven, 4 hours at 90° C	.8641	.4422	43.21	26.09	17.12
Top shelf water oven, 8 hours at 90° C	.8718	.4500	43.59	26.55	17.04
Top shelf water oven, 18 hours at 90° C	.8630	.4439	43.15	26.20	16.95
Second shelf water oven, 8 hours at 90° C	.8703	.4469	43.52	26.37	17.15
Second shelf water oven, 18 hours at 90° C	.8630	.4443	43.15	26.22	16.93
Third shelf water oven, 8 hours at 90° C	.8682	.4484	43.41	26.46	16.93
Third shelf water oven, 18 hours at 90° C	.8654	.4392	43.27	25.91	17.36
Bottom shelf water oven, 4 hours at 90° C	.8708	.4462	43.54	26.33	17.21
Bottom shelf water oven, 8 hours at 90° C	.8695	.4468	43.48	26.37	17.11
Bottom shelf water oven, 18 hours at 90° C	.8616	.4396	43.08	25.94	17.14

"I would suggest that for the sake of uniformity the time and temperature of drying be closely defined for the method; but I think my results show that the per cent of tannins is not largely influenced by variations in drying among various operators, provided they dry soluble solids and non-tannins under the same conditions at all times.

"The data I present seem to prove that the changes in weight of soluble solids and non-tannins are the same under the same conditions, and that, so far as the tannins are concerned, there is no difference in the time necessary for complete dehydration. It is only necessary, therefore, to define the time and temperature to be used."

Mr. Forbes states that after a careful investigation he found that no matter how long tanning liquor was passed through filter paper there was a slow but appreciable absorption of tanning matter; but that with an asbestos mat the absorption was nil. He communicated with the paper makers, but states that they failed to make a satisfactory paper from this material.

Mr. Forbes calls attention to the temperature of extraction of raw materials, the results shown by him in the paper read before this society last year on canaigre extraction, Bulletin No. 51, and the work of Proctor and Parker on various other materials on the same subject, and asks that this subject be given special attention.

Mr. Alsop presents the following data on the absorption of tanning matter by paper and kaolin:

A solution of gallotannin free from precipitate was continually filtered through doubled S. & S., No. 570, 15 cm filter paper, care being taken on the duplicates to have the paper weigh the same.

Original solids.	First solution, 0.8147 gram to 100 cc.		Second solution, 0.8182 gram.	
	Gram.	*Gram.*	*Gram.*	*Gram.*
First, 125 cc passing through	0.7905, loss	0.0242	0.7979, loss	0.0203
Second, 125 cc passing through	.8054, loss	.0093	.8117, loss	.0065
Third, 125 cc passing through	.8077, loss	.0070	.8093, loss	.0089
Fourth, 125 cc passing through	.8085, loss	.0062	.8169, loss	.0013
Fifth, 125 cc passing through			.8166, loss	.0016
Sixth, 125 cc passing through			.8146, loss	.0036

Ten grams kaolin were then thrown on the wet paper; on the first after 500 cc had passed through, on the second after 750 cc had passed through:

Original solids.	First solution.		Second solution.	
	Gram.	*Gram.*	*Gram.*	*Gram.*
First, 125 cc	0.7996, loss	0.0151	0.8174, loss	0.0008
Second, 125 cc			.8153, loss	.0029

By filtering with 10 grams kaolin on dry filter paper:

Original solids.	First solution.		Second solution.	
	Gram.	*Gram.*	*Gram.*	*Gram.*
First, 125 cc	0.7567, loss	0.0580	0.7705, loss	0.0477
Second, 125 cc	.7969, loss	.0178	.8075, loss	.0107

By filtering a hemlock liquor, free from precipitate, under the same conditions:

Original solids.	0.6378 gram per 100 cc.	
	Gram.	*Gram.*
First, 125 cc passing through	0.6225 per 100 cc, loss	0.0153
Second, 125 cc passing through	.6299 per 100 cc, loss	.0079
Third, 125 cc passing through	.6354 per 100 cc, loss	.0024
Fourth, 125 cc passing through	.6347 per 100 cc, loss	.0031
Fifth, 125 cc passing through	.6344 per 100 cc, loss	.0034
Sixth, 10 grams kaolin added	.6179 per 100 cc, loss	.0199
Seventh, 10 grams kaolin added	.6245 per 100 cc, loss	.0133
Eighth, 10 grams kaolin added	.6388 per 100 cc, gain	.0010

Ten grams kaolin on dry paper with this liquor gave:

Original solids.	0.6378 gram per 100 cc.	
	Gram.	*Gram.*
First, 125 cc passing through	0.6023 per 100 cc, loss	0.0355
Second, 125 cc passing through	.6280 per 100 cc, loss	.0098
Third, 125 cc passing through	.6322 per 100 cc, loss	.0056

This procedure was followed on extract solutions which had been filtered clear:

	Twenty grams to liter.		Ten grams to liter.	
	Gram.	*Gram.*	*Gram.*	*Gram.*
Original solids	0.8287		0.4085	
First, 125 cc passing through	.8175, loss.	0.0112	.4034, loss..	0.0051
Second, 125 cc passing through	.8215, loss..	.0072	.4069, loss..	.0016
Third, 125 cc passing through	.8237, loss..	.0050	.4081, loss..	.0004
Fourth, 125 cc passing through	.8233, loss..	.0054	.4100, gain..	.0015
Fifth, 125 cc passing through	.8286, loss..	.0001		
Sixth, 10 grams kaolin added	.8035, loss..	.0252	.3895, loss..	.0190
Seventh, 10 grams kaolin added	.8199, loss..	.0088	.4041, loss..	.0044
Eighth, 10 grams kaolin added			.4098, gain..	.0013

Ten grams kaolin on paper dry.

	Twenty grams to liter.		Ten grams to liter.	
	Gram.	*Gram.*	*Gram.*	*Gram.*
First, 125 cc passing through	0.7822, loss..	0.0465	0.3825, loss..	0.0260
Second, 125 cc passing through	.8262, loss..	.0025	.4004, loss..	.0081

The variations due to two kinds of filter paper are shown by the subjoined data. No. 602 S. & S. 15 cm is a hard-finished heavy paper while No. 590 S. & S., 15 cm is a soft-finished light paper. The extract used on this was the sample of grape sugar and gallotannin sent out by the referee. The official method of filtration was pursued, and the results are given under No. 1 and under No. 2; 150 cc of solution were thrown away and then 100 cc passed through the filter and evaporated.

	Number 1.		Number 2.	
	Gram.	*Gram.*	*Gram.*	*Gram.*
Original total solids	0.7685		0.7683	
No. 590 paper	.7483, loss..	0.0202	.7622, loss..	0.0063
No. 602 paper	.7106, loss..	.0579	.7585, loss..	.0103
No. 590 paper, 10 grams kaolin	.7286, loss..	.0399	.7600, loss..	.0085

These results show that under the present official method a certain amount of tannin is reported as reds and that by passing 150 cc of the solution through the paper before taking the 100 cc for soluble solids most of the error due to the absorption of the paper and also of the kaolin is obviated. It also shows that different kinds of paper absorb different amounts of tanning material. It will be seen by looking over these data that the absorption by the paper is considerable, but that upon continued contact of the paper and tan liquor the paper's affinity is satisfied. The extreme slowness of filtration that ensues from passing tannin solutions through the filter until the affinity of the paper is completely satisfied makes it impractical in the method, but since the error is quite small after 150 cc have passed through, I would suggest that the method in this particular, adopted by the International Association, be embodied in the official method, except in regard to the paper, where 590 S. & S. 15 cm should be substituted for 602 S. & S. paper. This makes the directions for filtration read: "Filtrations shall take place through S. & S., No. 590, 15 cm, and the first 150 cc passing through shall be rejected. Where a clear filtrate can not otherwise be obtained, the use of about 10 grams of kaolin previously washed with a portion of the tannin solution is permissible, but is to be noted in the report." "While this does not entirely obviate the difficulty, it leaves a very small error due to this cause and seems the only practical way out."

The soluble material in the hide and the quantity of dry hide used are presented in the following table. Hide "A" is that sent out with the first sample marked "A," Vienna hide; "B" is that sent out with first sample marked "B," Ridgeway hide; "C" is that sent out with the second sample and is Vienna hide.

The samples are, No. 1, chestnut-wood extract; No. 2, hemlock liquor, and No. 3, grape sugar and gallotannin extract.

In no case does the soluble material in the hide powders exceed the limits of the method.

TABLE No. 4.—*Soluble material in and quantity of dry hide used.*

Name.	Solubles in hide.			Dry hide No. 1, sample "A" hide.	Dry hide No. 1, sample "B" hide.	Dry hide No. 2, sample "A" hide.	Dry hide No. 2, sample "B" hide.	Dry hide No. 3, sample hide.
	"A."	"B."	"C."					
	Gram.	*Gram.*	*Gram.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Allaire	0.0070	0.0075	....	15.43	13.98	12.99	12.55	....
Alsop	.0025	.0030	0.0026	12.00	12.00	12.00	12.00	12.00
Carr	.0050	.0100	....	16.50	16.50	14.75	14.75	....
Eachus	.0020	.0035	.0020	12.00	12.50	12.00	12.50	12.00
Eitner (Weiss)	....	....	....	12.42	11.97	12.42	11.97	....
Forbes	.0030	.0028	.0025	11.48	10.14	13.05	11.89	....
Haley	.0040	.0020	.0010	12.40	13.20	9.30	9.90	11.20
Hurty	.0039	.0041	.0066	11.37	12.23	11.77	14.39	....
Krug	.0061	.0039	....	....	....	....	....	....
Kerr	....	....	.0065	....	....	....	....	11.15
Lowell	.0026	.0046	....	11.73	11.95	10.56	11.83	....
McDowell	.0070	.0090	.0030	13.92	15.12	11.84	12.60	11.55
Nichols	....	....	.0070	....	....	....	....	....
Proctor	.0050	.0040	....	10.50	12.24	12.81	13.47	....
Small	.0026	.0022	....	11.44	11.90	12.88	11.82	11.52
Tiffany	.0100	.0060	....	12.35	12.50	....	....	....
Yocum	.0030	.0040	.0030	12.00	11.50	11.50	11.50	12.00

In the table of results on the chestnut-wood extract the difference between maximum and minimum of solids is 1.48 per cent. This is wholly due to variations in drying. The difference in soluble solids is 3.23 per cent. Assuming that the drying variations are the same as for solids, then the variation due to filtering is 1.75 per cent. The differences on non-tannins is 2.09 per cent. On the above assumption that 1.48 per cent difference is due to drying, then 0.61 per cent is the difference in the non-tannin determination proper. From this it is readily seen that drying and filtering are the greatest sources of variations in the tannin determination.

The hemlock liquor sent out as a sample was free from insoluble matter, yet there was reported a mean of 0.11 per cent of reds, which was undoubtedly due to an error in the method for determining them. The same thing occurs in the grape sugar—gallotannin extract, which contained no reds, yet was reported as containing on the average 1.35 per cent; the sum of the reds and tannins, 19.89, being nearly the same as the theory for tannin in this sample, 20.19 per cent. Theory gave 37.77 per cent solids, the mean of the results 38.79, a difference of 1.02 per cent, due to incomplete drying, no doubt. On non-tannins, theory gave 17.58 per cent, the mean of the results 18.90, a difference of 1.32, within 0.30 per cent the same as the difference in solids, which was due to drying entirely. From these data I think it fair to conclude that the non-tannin determination is a satisfactory one, except in regard to drying.

There seems to be no question but that the cellulose of the filter paper removed tannin to the extent of a mean of 1.35 per cent. On the other hand, in many commercial extracts a complete removal of the reds is not effected by the directions of the method for filtering, the reds being such a fine precipitate that they practically all pass through the filter. Some means of obtaining a solution free of this precipitate, and yet not having the absorption of the paper enter into the determination, must be devised before the soluble solid determination will be satisfactory. Mr. Forbes suggested an asbestos filter paper, but this can not be obtained. Mr. Alsop suggests satisfying the affinity of the paper for tannin by passing 150 cc through, and the use of kaolin, washed in the tannin solution before use, as a means of obviating both difficulties. This seems to me the only feasible means of obtaining satisfactory results, but even by this a slight error will remain.

The results of the work of Messrs. Carr and Eachus in regard to drying show the difficulties and errors of the present system. Mr. Carr's suggestion "to dry in vacuo at 70° C." would, in all probability, be the most satisfactory if it could be generally pursued, but I doubt if such a proviso could be enforced.

With this same difficulty in the determination of water in sugar solutions, sirups, etc., this association has not adopted the vacuum apparatus.

The data presented by Mr. Eachus would lead one to believe that in this determination, if the solids be exposed to decomposition in drying under the same conditions as the non-tannins, the actual loss of weight in each will be such as to give the same result in tannins.

The variations due to the various ways of drying are shown in the following table:

[Water oven, temperature, 90° C.; time, twenty-four hours. Air oven, temperature, 100° to 104° C.; time, four hours. Vacuum oven, temperature 100° C.; time, two and one-half hours; 20 inches vacuum.]

Sample.	No. 1.	No. 2.	No. 3.
	Gram.	*Gram.*	*Gram.*
Water oven	0.8241	0.7177	0.7060
Air oven	.8119	.7063	.6986
Vacuum oven	.8224	.7151	.7056

It would seem that to obtain any degree of concordance it is necessary to have the method of drying outlined with considerable exactness, both in regard to time and temperature, and it would seem to your referee a fitting subject for the forthcoming year's investigation. For the present, drying for eight hours at 100° C. in an air oven or eighteen to twenty hours in a water oven at 90° C. seems the least objectionable.

In the direct determination of water in extracts, etc., it is essential that the extract be evenly deposited as a film on the bottom of the containing vessel. This is best effected by diluting in the vessel with about 25 cc of water before evaporating. It seems better to make the directions read that 1 gram of solids will remain after drying, instead of, as now, "use 3 grams of the extract," for owing to the varying concentration of extracts sometimes the film is much too thick to dry well.

On September 30, 1897, there was organized in London the International Association of Leather Trades' Chemists, whose object is the promotion and adoption of standard methods of tannin analysis. This association received the support of practically all the Continental and English chemists interested, and after a great deal of discussion they adopted the following method for tannin:

METHOD.

PREPARATION.

Liquid extracts.—Liquid extracts shall be rapidly stirred and mixed immediately before weighing, which shall be done rapidly to avoid loss of moisture. Thick extracts which can not be otherwise mixed may be heated to 50° C., then stirred, and rapidly cooled before weighing.

Barks and solid tanning materials.—The whole sample, or not less than 250 grams, shall be ground in a mill until it will pass a sieve of five wires per centimeter. Materials such as barks, divi-divi, etc., containing fibrous material, shall be sieved and proportionate parts of the fibrous substance and that passing through sieve employed.

Strength of solution.—Such solutions shall be employed that, upon the evaporation of 100 cc the residue shall amount to between 0.6 and 0.8 gram.

Solution of liquid extracts.—A sufficient quantity shall be weighed into a covered basin or beaker, from which it shall be washed into a liter flask with about 500 cc of boiling water and well shaken, and the flask shall be filled nearly to the mark with cold water, the neck being covered with a small beaker; it shall be placed under a cold-water tap, or otherwise rapidly cooled to a temperature between 15° and 20° C. and made up to the mark, after which it shall be thoroughly mixed and immediately filtered.

Filtration.—Filtration shall take place through S. & S. filter paper No. 602. The first 150 or 200 cc of the filtrate shall be rejected. Where a clear filtrate can not be otherwise obtained, the use of a little kaolin previously washed with a portion of the tannin solution is permissible.

Extraction of solid materials.—Such quantity shall be weighed as will give an infusion of the strength already prescribed. Not less than 500 cc of the infusion shall be extracted at a temperature not exceeding 50° C., after which the temperature shall be raised to 100° C. and the extraction continued till the percolate is free from tannin and the whole made up to 1 liter, the weaker portion being concentrated if necessary by evaporation.

Total soluble matter.—One hundred cc of the clear filtered tanning solution shall be evaporated on the water bath and shall afterwards be dried in an air oven, to constant weight at a temperature of 100° to 105° C., or at a temperature not exceeding 100° C. in vacuo.

Determination of non-tannins.—The filter-tube method shall be adopted provisionally.

The Bell form of filter shall be employed. Not less than 5 grams of hide powder shall be used, and the filtrate shall be rejected so long as it gives a turbidity with a clear tannin solution. The filtrate may be used for the determination of non-tannins so long as it gives no reaction with hide-powder water (a clear solution of soluble gelatin from the hide). Fifty cc or less quantity of detannized solution shall be evaporated on a water bath and dried as directed for soluble matter.

The main difference between this and the official method of this association is in the non-tannin determination. The results from the filter tube are invariably lower than those obtained by the shaker. Messrs. Weiss, Proctor, Parker, and Tonse report results on the chestnut-wood extract and hemlock liquor by this method.

	Extract.	Liquor.
	Per cent.	*Per cent.*
Weiss, nontannin	13.90	2.13
Proctor, nontannin	11.80	2.16
Parker, nontannin	12.10	2.00
Tonse, nontannin	12.25	....
Weiss, tannins	25.24	2.50
Proctor, tannins	27.90	2.45
Parker, tannins	28.00	2.80
Tonse, tannins	27.91	....

It is hoped that the more general use of the shaker method abroad will convince the foreign chemist of its superiority and that it will be incorporated in their method.

The manufacturers of extract are varying the concentration of their product much more now than in the past, and as the present method calls for 20 grams of extract per liter the solids per 100 cc of working solutions vary considerably, and inasmuch as these variations in concentration influence the results on both non-tannins and soluble solids a more definite statement regarding quantity of material is necessary.

An extract diluted 20 grams to the liter, giving 1.0648 grams of solids per 100 cc of solution, and the same extract dissolved so that 100 cc of solution had 0.8000 gram solids, gave:

	Twenty grams to liter.	0.8 gram per 100 cc.
	Per cent.	*Per cent.*
Soluble solids	50.00	51.15
Non-tannins	19.44	18.46

Uniformity in the quantity of hide and strength of solution are both necessary for concordance in the results on non tannins, as has been proven, and with the absolute definition of the quantity of solids per 100 cc of solution and the use of a certain quantity of hide powder this error is eliminated.

The directions for washing the hide powder as a preliminary to the non-tannin determination are quite complicated and lengthy. To determine if some better means could not be devised several experiments were carried on, and it was found that by using about twenty-five times as much water as hide, by weight, a very satisfactory washing could be effected by one treatment.

Twenty grams of hide and 500 cc of water were used in the following tests; the hide was well stirred in a large beaker, fresh water was used, and the hide and water stood one hour for each washing:

	Gram.
First washing, 100 cc, evaporated	0.1014
Second washing, 100 cc, evaporated	.0070
Third washing, 100 cc, evaporated	.0061
Fourth washing, 100 cc, evaporated	.0079

If the hide answer the tests outlined under Paragraph VIII of the method, the preparatory washing can be much simplified and one of the most tiresome and objectionable points of the method obviated.

RECOMMENDATIONS.

Your referee makes the following recommendations:

That Paragraph II of Method, "Quantity of material," shall read:

"In the case of bark and similar material use such quantity as will give about 0.8 gram solids per 100 cc of solution, extract in Soxhlet or similar apparatus at steam heat for non-starchy materials. For canaigre and substances containing like amounts of starch use temperature of 50° to 55° C. until near complete extraction, finishing the operation at steam heat. In the case of extract weigh such quantity as will give 0.8 gram solids per 100 cc of solution, dissolve in 900 cc of water at 80° C., let stand twelve hours, and make up to 1,000 cc."

That Paragraph III shall read:

"Weigh 2 grams if it be an extract into a flat-bottomed dish not less than 2½ inches in diameter; add 25 cc of water, warm slowly till dissolved; continue evaporation and dry."

That the following be inserted as IIIa:

"All dryings called for, after evaporation to dryness on water bath or others, shall be done by one of the following methods, the soluble solids and non-tannins being dried under similar, and so far as possible, identical conditions:

"A. For twenty-four hours at the temperature of boiling water in a steam bath.

"B. For eight hours at 100° to 103° C. in an air bath.

"C. To constant weight in vacuo at 70° C.

"State in report the method of drying pursued."

That Paragraph V shall read:

"Filtration shall take place through a double folded filter (S. & S. No. 590), the first 150 cc passing through shall be rejected, 100 cc next passing through shall be evaporated and dried. When a clear filtrate can not be otherwise obtained the use of 10 grams of kaolin previously washed in a portion of the tanning solution is permissible. Evaporation during filtration must be guarded against."

That Paragraph VI shall read:

"Prepare 20 grams of hide by washing in a No. 7 beaker (Griffin) with 800 to 1,000 cc of water, stir well and let stand one hour; filter the magma through linen, squeeze thoroughly by hand and remove as much water as possible by means of a press, etc." (From here the same as in Bulletin No. 51.)

That the following be inserted as VIIa:

"A. That the temperature of solutions shall be between 16° and 20° C. when measured or filtered.

"B. Dryings to be made in flat-bottomed dishes not less than 2½ inches in diameter."

No papers were presented on the subject of tannin.

The committee on recommendations here presented its report in favor of the adoption of the recommendations of the referees on food adulteration and tannin. The report was adopted.

Dr. De Schweinitz then read his report on the determination of nicotin, as follows:

REPORT OF AN INVESTIGATION OF THE METHODS FOR THE DETERMINATION OF NICOTIN IN TOBACCO POWDERS AND EXTRACTS.

By E. A. DE SCHWEINITZ, with the cooperation of J. A. EMERY and F. K. CAMERON.

Having had occasion to examine the nicotin content of a number of tobacco extracts, my attention was called to the fact that by the best method, namely the Kissling, which is ordinarily used, the results are not always concordant.

It occurred to me, therefore, that it might be of considerable interest to have a number of different men make analyses of the same samples. I wrote to Dr. Winton, president of the association, in regard to the matter, and he said that I should proceed with the work and agreed to cooperate in it. Accordingly, I secured samples of two tobacco powders and two tobacco extracts from Dr. Walker Bowman, of the Louisville Spirit Cure Tobacco Company, and had duplicate samples bottled and sent to the following gentlemen who had agreed to aid in the work: Prof. R. J. Davidson, of Blacksburg, Va.; Prof. J. H. Patterson, Maryland Agricultural College; Dr. A. L. Winton, of Connecticut, and Dr. Walker Bowman, of the Louisville Spirit Cure Tobacco Company, and in my laboratory the work was done by Mr. James A. Emery and Dr. Frank K. Cameron. Three methods were prescribed, namely, the Kissling, the use of Lloyd's reagent, and the optical method. All of the gentlemen carried out the work according to Kissling's method, but only two or three used the optical method or Lloyd's reagents.

The outlines of the several methods used are as follows:

Kissling's Method.[1]—Extraction of the alkaline magma with ether evaporation, distillation, etc.

The use of Lloyd's reagent.—The outline of this method is as follows: Five cc of the solution or extract are placed in an extra heavy beaker and enough of Lloyd's reagent for alkaloids (equal parts dry ferric hydrate and sodium bicarbonate) is then added to make a very stiff magma or paste. Twelve cc of rectified petroleum ether are then added to the contents of the beaker, and the whole rapidly agitated. The petroleum ether is then decanted into a small separating funnel and the operation repeated upon the pasty mass with 11, 10, 9, and 8 cc of ether in turn. The ether extracts are mixed together in the separating funnel and 5 cc of normal sulphuric acid with 15 cc of water added to the contents. The whole is rapidly shaken and the lower layer withdrawn. The ether is again washed with 10 cc and 5 cc of water and the washings, together with the acid extract, titrated with one-fifth normal potassium hydrate, litmus being added as an indicator. Each cubic centimeter of alkali used in excess of that necessary to neutralize the acid is equal to 0.0324 gram nicotin.

The optical method.—The optical method described by Popovici (Ztschr f. Physiol. Chemie, Vol. XIII, p. 445; also Chem. Ztg. 1889, p. 1030). The outline of the method is as follows:[2]

The tobacco is extracted with ether as in Kissling's method, and the extract from 20 grams of tobacco is mixed with 10 cc of a fairly concentrated nitric acid solution of phosphomolybdic acid, which throws down the nicotin, ammonia, and so on, as a precipitate which separates readily. The ether is then carefully poured off and the residue is made up to a volume of 50 cc by the addition of distilled water. Eight grams of finely powdered barium hydrate are then added for the purpose of setting the nicotin free. As this decomposition takes place somewhat slowly, the flask containing the mixture should be allowed to stand for several hours and be shaken from time to time. The precipitate, which is at first blue, gradually changes to a blue-green, and finally to a yellow. The alkaline solution which contains the nicotin is filtered off and the yellow-colored filtrate is polarized. The reading on the polariscope in minutes is noted. From this reading, in combination with the table which can be found in Kissling's Tabakkunde, page 68, the percentage of nicotin can be determined. The results reported by the different gentlemen who carried out the work can be seen in the following table:

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[1] Wiley, Principles and Practice of Agricultural Analysis, Vol. III, p. 606.

[2] Vide Principles and Practice of Agricultural Analysis, Vol. III, p. 607.

Tobacco powders.

Analyst and location.	No. 1.				No. 2.			
	Kissling.	Lloyd.	Optical.	Average.	Kissling.	Lloyd.	Optical.	Average.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
A. L. Winton, Connecticut	0.70	....	....	....	1.67	....	....	K=1.70
				K=0.67	1.73			
	.65							
H. J. Patterson, Md. Agr. Ex. Sta.	.53	....	....	K= .53	1.36	....	....	K=1.36
R. J. Davidson, Va. Agr. Ex. Sta.	.81	0.90	1.42	K= .81	1.85	1.94	....	K=1.83
	.81	....	....	L= .90	1.81	1.81	....	L=1.87
				O=1.42				
Walker Bowman, Louisville, Ky.	.77	....	....	K= .77	2.52	....	....	K=2.52
J. A. Emery, U. S. Biological Chemical Laboratory.	.58	.50	....	K= .58	2.56	2.05	1.75	K=2.56
				L= .50	....	....	....	L=2.05
								O=1.75

Tobacco extracts.

Analyst and location.	No. 3.				No. 4.			
	Kissling.	Lloyd.	Optical.	Average.	Kissling.	Lloyd.	Optical.	Average.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
A. L. Winton, Connecticut	3.60	....	....	K=3.64	12.66	....	....	K=12.76
	3.64	....	....	....	12.87			
	3.68							
H. J. Patterson, Md. Agr. Ex. Sta.	3.05	....	....	K=3.05	9.92	....	....	K= 9.92
R. J. Davidson, Va. Agr. Ex. Sta.	3.93	4.14	4.13	K=3.95	11.73	11.21	10.90	K=11.75
	3.98	3.95	4.00	L=4.02	11.77	9.91	....	L=10.56
				O=4.06	....	....	....	O=10.90
Walker Bowman, Louisville, Ky.	4.24	....	....	K=4.24	9.11	....	....	K= 9.11
F. K. Cameron, U. S. Biological Chemical Laboratory.	2.50	....	....	....	10.80			
	2.50	....	....	....	11.50			
	2.52	....	....	K=2.54	11.06			
	2.76	....	....	....	14.40	....	....	K=12.36
	2.90	....	....	....	11.40			
	2.20	....	....	....	15.10			
	2.40	....	....	....	11.60			
					13.07			
J. A. Emery, U. S. Biological Chemical Laboratory.	3.91	3.88	....	K=3.91	14.70	13.35	10.00	K=14.70
		3.80	....	L=3.84	....	13.38	....	L=13.40
						13.47	....	O=10.00

The very great variation in these results from the same samples in the hands of different men made me think that a still more extensive study than that which I had intended originally was desirable. Accordingly, Mr. James A. Emery and Dr. Frank K. Cameron undertook a very thorough investigation of the subject. We have tried all manner of modifications of the ordinary methods and a large number of new methods, that will be noted below, without having been able as yet to hit upon a method which would be surely accurate. The sources of error in the Kissling method were found to be due to ammonium salts and the amins, which it is very difficult to separate from nicotin on account of the fact that the salts which all three of these form are so nearly alike. We note briefly some of the different methods which we have tried to adapt to a more careful separation of the nicotin from ammonium salts and amins.

THE FORMATION OF AN INSOLUBLE PRECIPITATE.

So far none has been found to which there are not serious objections as a practicable analytic method. The picrate is quite measurably soluble. The phosphotungstate, phosphomolybdate, etc., are too nearly alike in their general physical properties to the corresponding salts of other organic nitrogenous bases to make a satisfactory separation possible. The insoluble double salts with metallic bases are dependent on conditions of temperature and concentration to such an extent as to make the precipitation of any definite compound too uncertain under ordinary working conditions. Some of these objections will be further discussed presently.

ROTATORY EFFECT OF SOLUTIONS ON PLANE OF POLARIZED LIGHT.

An elegant method depending on this principle has been suggested by Popovici; but the possibility of errors incident to the preparation of the solutions is great. The presence of optically active solutes other than nicotin is not considered. For these or other possible reasons this method has not found favor with analysts. A further minor objection, but one greatly to be regretted, is that few laboratories have the necessary instrumental equipment.

PRECIPITATION WITH PICRIC ACID.

Preliminary experiments with tobacco extracts having indicated the possibility of this method being used, the following experiments were made:

Experiment 1.

To solution known to contain nicotin, 0.52245 gram.

Added 10 cc N/2 HCl.

Added saturated solution of picric acid to excess.

Heated to 98° C., then cooled slowly to room temperature and allowed to stand twenty-four hours.

Filtered precipitate and washed with 100 cc water.

Weight of precipitate, 1.79700 grams.

By calculation [$C_{10}H_{14}N_2—2C_6H_2(NO_2)_3OH$] gave nicotin 0.4695 gram, or 89.86 per cent recovered.

The precipitate was dissolved in 20 cc N/2 NaOH, distilled in current of steam into 41 cc N/2 HCl; about 1,000 cc in distillate.

	Cubic centimeters.
41 cc N/2 acid were equivalent in alkali to	205.00
Distillate equivalent in alkali to	170.40
Nicotin equivalent in alkali to	34.60

34.6 cc alkali were equivalent in acid N/2 to 6.92 cc.

34.6 cc alkali were equivalent in nicotin to 0.56052 gram, or 107.28 per cent recovered.

The filtrates from nicotin picrate and washings were made alkaline with soda and distilled with steam into 20 cc N/2 acid, about 700 cc in distillate.

	Cubic centimeters.
20 cc N/2 acid were equivalent in alkali to	100.00
Distillate	98.50
Nicotin	1.5
1.5 cc alkali were equivalent in N/2 acid to	.30

	Gram.
1.5 cc alkali were equivalent in nicotin to	0.0243
Nicotin from precipitate (original)	.4695
Nicotin from filtrate	.0243
	.4938

Percentage recovered, 94.51.

Nicotin from distillate (original)	.56052
Nicotin from filtrate	.02430
	.58482

Percentage recovered, 111.97.

Experiment 2.

	Gram.
Solution known to contain nicotin	0.74196
Ammonia	.08500
Trimethylamin	(?)

Added H_2SO_4 solution to slight excess. Then a saturated solution of picric acid to excess. Heated until precipitate was entirely dissolved and then cooled gradually, finally standing the containing flask in an ice-water bath.

Filtered and washed with 150 cc water, in three portions, sucking dry each time with the aid of the pump. Dried precipitate at 120°.

Weight of precipitate, 2.6708 grams.

By calculation [$C_{10}H_{14}N_2—2\ C_6H_2(NO_2)_3OH$] gave nicotin 0.6934 gram, or 93.4 per cent recovered.

The filtrate was brought into a flask with a rather large excess of soda, and distilled in a current of steam into 30 cc N/2 HCl and titrated back with soda.

Distillate was equivalent in N/2 acid to 12.52 cc.

Nicotin in distillate was equivalent to 1.01412 grams, or 136.7 per cent recovered.

From these experiments (1 and 2) it would appear that either all the nicotin was not precipitated, or that nicotin picrate is decidedly more soluble than the rather vague statements in the literature would indicate. Therefore the following experiments were made:

Experiment 3.

[Solubility of nicotin picrate at 20.5°.]

	Grams.
Solution containing nicotin picrate weighing	9.9723
Evaporated to dryness, nicotin picrate weighing	.0055
Water	9.9668

One gram of water contained 0.0005519 gram nicotin picrate.

Solubility (uncorrected) of nicotin picrate in water, 0.5519 gram per liter.

Experiment 4.

	Grams.
Solution containing nicotin picrate weighing	9.9774
Evaporated to dryness, nicotin picrate weighing	.0055
Water	9.9719

One gram of water contained 0.0005515 gram nicotin picrate.

Solubility (uncorrected) of nicotin picrate in water is 0.5515 gram per liter.

Average solubility: 1 part of nicotin picrate in 1,813 parts of water.

In experiments 1 and 2 about 500 cc of water for solution and washings were used. A loss of 0.25 gram, approximately, could therefore be expected.

For experiment 1, actual loss in percentage, 10 per cent; calculated, 14 per cent.

For experiment 2, actual loss in percentage, 6.5 per cent; calculated, 9 per cent in round numbers. It was thought desirable to determine with approximate accuracy the probable loss from washings of the precipitate, therefore the following experiments were made:

Experiment 5.

Precipitated 16 cc nicotin solution and weighed in a gooch.

	Grams.
Weight of nicotin picrate and gooch	27.5075
Weight of gooch	25.4194
Weight of nicotin picrate	2.0881

16 cc nicotin solution equal 7.36 cc N/2 HCl equal 0.59616 gram nicotin; 2.2815 grams nicotin picrate.

2.0881 grams nicotin picrate equal 0.54562 gram nicotin; 91.52 per cent nicotin recovered.

0.1934 gram nicotin picrate was lost in solution.

8.47 per cent nicotin picrate were lost in solution.

Experiment 6.

Took No. 1 gooch and added crystals of nicotin picrate crystallized from hot solution.

	Grams.
Weight of nicotin picrate and gooch	26.9080
Weight of gooch	26.7107
Weight of nicotin picrate	0.1973

Washed with aid of vacuum pump with 250 cc distilled water at temperature of 23° C., filling the gooch each time and then sucking dry before adding more water, dried and weighed.

	Grams.
Weight of nicotin picrate and the gooch	26.8761
Weight of gooch	26.7107
Weight of nicotin picrate	0.1654

16.22 per cent were lost by washing.

It follows from the above results that the estimation of nicotin as picrate is open to grave objections, as under the usual conditions of work a control of the amount lost in the washing is quite impracticable. It follows, further, from experiments 1 and 2, that a quantitative recovery of the nicotin from the picrate, which it was hoped would serve as a check, is not possible, at least by distilling with steam from an alkaline solution. The contents of the flask from which the distillation was making gradually became darker and darker, and the experiments quoted, together with others which we made, showed that very great decomposition took place, depending on the time of heating and the concentration of the flask contents.

PRECIPITATION WITH PHOSPHOMOLYBDIC AND PHOSPHOTUNGSTIC ACIDS.

Pyridin and the aliphatic amins were found to yield precipitates so nearly identical in physical properties, conduct toward solvent, etc., with those from nicotin that all attempts to found a method of separation upon them were unavailing.

PRECIPITATION AS DOUBLE SALTS WITH METALLIC BASES.

In all cases to which reference could be found in the literature, it was evident that the salt in question was one of a series, and that in practice the composition of the precipitate would be too uncertain to be of value. No experiments were made in this direction.

PRECIPITATION WITH BROMIN AND IODIN.

In neutral or acid solution nicotin forms insoluble addition products with bromin and iodin. Repeated efforts were made to utilize these facts, but the precipitates were in all cases gummy or pasty, so filtration was impracticable. Working in ether as a solvent no better results could be obtained. The precipitation of the nicotin with bromin and washing it free from other substances by decantation was tried. The nature of the precipitate made the process itself a rather difficult one; but farther, the precipitate decomposed on standing or heating alone, with water, or with alkaline solutions, with the formation of a greater or less amount of tar. The recovery of the nicotin quantitatively was impracticable.

Of the methods in use the one which has found most favor with analysts, and justly so, is known by the name of its author as the Kissling. Briefly, it consists in mixing intimately the material with alcoholic potash, the extraction of the nicotin with some suitable solvent (ether is generally recommended), removal of the solvent by evaporation at as low a temperature as practicable, and separation of the nicotin from the residue by distilling from an alkaline solution in a current of steam. A systematic examination of this method was deemed advisable, therefore the following experiments were made.

The extraction of the material was conducted in the following manner: An apparatus was arranged, consisting of a glass tube with a cross section about 45 mm in diameter, about 225 mm in length, drawn out to a narrow tube at the bottom, and fitted into a small Florence flask, about 250 cc capacity, with a well-fitting rubber stopper. The larger end was closed with a rubber stopper carrying a long condenser. The material to be extracted was placed in a cone or cylinder, made by folding a sheet of filter paper over a cylinder of wood or some suitable material, rolling it until of desirable thickness, and then holding it in position by tying with a piece of thin wire. This cylinder was then placed in the tube just mentioned. The paper cylinder may be kept from stopping the tube by first introducing a piece of broken glass or similar material, but our experience showed this precaution to be required but very seldom. When properly arranged, this is a most rapid and effective instrument for continuous extraction at a temperature but little below the boiling point of the solvent, and has the advantage of simplicity and that it can be constructed by anyone with usual laboratory material. When liquid extracts were under investigation they were first absorbed by precipitated calcium or magnesium carbonate and then treated in the usual manner.

Experiment 9.

Some qualitative experiments were made to test the value of ether, benzene, ligroin, and alcohol as solvents for extraction. Their desirability for the purpose was found to be in the order named, with a very decided preponderance in favor of the first mentioned. A further description of these experiments seems hardly worth while.

Experiment 10.

Some odor of nicotin was found to be present in material which had been subjected to extraction as above described, therefore extractions were made of widely varying amounts of material for a certain number of hours. The operation was discontinued, a fresh quantity of solvent introduced, and the contents of the second extract estimated. The results are here tabulated:

Solvent.	First extraction.	Second extraction.	Second extraction.
	Hours.	*Hours.*	*Per cent.*
Ligroin	12	6	0.016
	12	6	0004
Benzene	3	6	0000+
	3	6	0000+
Ether	3	6	0000+
	3	6	0000+

It follows that no appreciable error is to be expected from this source.

We next tested the extraction of nicotin by ether, to find out the probable error introduced by the evaporation of the solvent. We had been using the device of acidifying the extract before driving off the ether, but the result of the following experiment showed this to be an unnecessary refinement and further had the disadvantage of retaining ammonia and other very volatile basic constituents which would have been more or less completely removed with the ether.

Experiment 11.

Started with nicotin (Merck) 1.4186 grams dissolved in 25 cc ether (c. p. Squibb).
Evaporated slowly. Dissolved residue in water and made up to 100 cc.
Added 40 cc N/2 HCl and titrated, requiring 39.4 cc soda solution.

	cc
40 cc N/2 acid are equivalent in soda	68.92
Solution equivalent in soda to	39.40
Nicotin equivalent to	29.52

29.52 cc alkali equivalent to N/2 HCl 17.13 cc.
29.52 cc alkali equivalent to nicotin 1.3875 grams, or 97.74 per cent, recovered
Checked with the following experiment:
Started with nicotin (Merck.) 0.9042 gram made up to 100 cc in water.

Added 20 cc N/2 acid equivalent to	34.46 cc alkali.
Nicotin + N/2 acid equivalent to	15.60 cc alkali.
	18.86 cc alkali.

18.86 cc alkali are equivalent to 10.94 cc N/2H_2SO_4.
18.86 cc alkali are equivalent to 0.8860 gram nicotin.
97.99 per cent nicotin in original substance.
Loss by extraction with ether and evaporation, 0.25 per cent.

The efficiency of distillation in a current of steam as a method of recovering the nicotin was then tested by the following experiment:

Experiment 12.

Started with solution containing nicotin, 1.3867 grams.
Added 15 cc alkali [1.723 alk = 1 cc N/2 acid].
Distilled 400 cc into 30 cc N/2 H_2SO_4.

30 cc N/2 H_2SO_4	51.69 cc alkali.
30 cc N/2 H_2SO_4 and nicotin in distillate	26.25 cc alkali.
Nicotin equivalent to	25.44 cc alkali.

25.44 cc alkali equivalent to 14.75 cc N/2 acid.

25.44 cc alkali equivalent to 1.1948 grams nicotin.

86.1 per cent of nicotin recovered.

Continued distillation, 400 cc into 10 cc N/2 H_2SO_4.

10 cc N/2 H_2SO_4 required alkali	17.23	cc
10 cc N/2 H_2SO_4 plus nicotin	13.20	
Nicotin equivalent to	4.03	cc
4.03 cc alkali equivalent to N/2 H_2SO_4	2.34	
4.03 cc alkali equivalent to nicotin	0.1893	gram

99.81 per cent nicotin recovered.

The practice here differed from that recommended by Kissling. According to his directions the distillation should be so conducted that the contents of the flask from which the distillation is taking place should rapidly diminish in volume. But experience led us to believe this bad practice, on account of the probable decomposition of the nicotin and other organic nitrogen bases present in the more concentrated alkali. The above-described experiment shows that a much larger volume must be distilled if the contents of the distillation flask are to be kept approximately constant. We believe the latter practice to be much the more desirable.

This experiment was repeated, starting with nicotin and ammonia.

Experiment 13.

Took solution containing nicotin 1.8826 grams and 100 cc solution of ammonia, equivalent to 35 cc N/2 H_2SO_4.

Added 50 cc soda solution [1.723 cc alk. = 1 cc N/2 acid].

Distilled 800 cc into 100 cc N/2 H_2SO_4 and titrated with standard alkali.

100 cc N/2 H_2SO_4 are equivalent to	172.30 cc soda.
Distillate is equivalent to	85.50 cc soda.
Nicotin and ammonia are equivalent to	86.80

86.80 cc alkali are equivalent to 50.38 cc N/2 H_2SO_4.

Original solution before distillation required 51 cc N/2 H_2SO_4.

98.79 per cent volatile alkali recovered. That is to say, that practically all the ammonia, as well as nicotin, was recovered. But the following experiments indicate that the ammonia is effectively eliminated in the evaporation of the solvent from the ether extract. The method employed is that of Kissling with these modifications—that the contents of the distilling flask are kept at an approximately constant volume and the distillate is always acid.

Experiment 14.

To 10 cc nicotin solution, containing 0.35721 gram nicotin, added 10 cc N/2 NH_3 and 5 cc of alcoholic soda (made up per Kissling) with $CaCO_3$; extracted with ether in continual extraction apparatus; evaporated ether and made alkaline with soda solution and distilled with steam into flask containing 20 cc N/2 HCl until 400 cc distillate had collected; then put into flask containing 10 cc N/2 HCl and continued until 400 cc more had distilled over.

20 cc N/2 HCl equivalent to	100 cc N/10 soda.
20 cc N/2 HCl plus nicotin equivalent to	78.8 cc N/10 soda.
Nicotin equivalent to	21.2 cc N/10 soda.
10 cc N/2 HCl equivalent to	50.0 cc N/10 soda.
10 cc N/2 + nicotin equivalent to	49.3 cc N/10 soda.
	.7 cc N/10
	21.2 cc N/10
	21.9 cc N/10

= 4.38 cc N/2 HCl, or 99.32 per cent nicotin recovered.

Experiment 15.

Started with solution containing nicotin 0.1786 gram (5 cc N/2 NH_4OH solution).

5 cc alcoholic soda (Kissling) absorbed with sufficient calcium carbonate.

Extracted with ether 6 hours.

Evaporated ether, dissolved residue in 50 cc N/10 NaOH and distilled 700 cc in 25 cc N/2 HCl.

25 cc N/2 acid equivalent to	125 cc N/10 alkali.
Distillate equivalent to	114 cc N/10 alkali.
Nicotin equivalent to	11 cc N/10 alkali.

11 cc N/10 alkali equivalent to 2.2 N/2 acid.

11 cc N/10 alkali equivalent to 0.1782 gram nicotin.

99.78 per cent were recovered.

Experiment 16.

Solution containing nicotin 0.35721 gram and 5 cc N/2 NH_4OH solution and 5 cc alcoholic solution NaOH (Kissling). Absorbed mixture with sufficient calcium carbonate. Extracted with ether for three hours. Evaporated ether. Made alkaline. Distilled 700 cc into 30 cc N 2 HCl, and titrated back with alkali solution.

	cc.
30 cc N/2 acid equivalent to	30.3
Distillate equivalent to	26.0
Nicotin equivalent to	4.3

97.5 per cent nicotin recovered.

These results were satisfactory. But when trimethylamin was present in the original solution it was not removed by the process, and, judging from the results of the next experiment, the removal of ammonia was also very much less effective.

Experiment 17.

Solution containing nicotin 0.18549 gram and 5 cc trimethylamin hydrochlorid (dilute solution, strength unknown) and 5 cc N/2 NH_4OH solution and 5 cc alcoholic soda (Kissling).

Absorbed with powdered Mg CO_3; extracted with ether for upward of three hours. Evaporated extract. Dissolved residue in 50 cc N/10 NaOH solution.

Distilled 800 cc with steam into 30 cc N/2 HCl.

30 cc N/2 HCl equivalent to	150.00 cc N/10 NaOH
Distillate equivalent to	136.80
Nicotin equivalent to	13.20

13.2 N/10 NaOH equivalent to 2.64 N/2 HCl.

13.2 N/10 NaOH equivalent to 0.21384 gram nicotin.

115.28 per cent nicotin were recovered.

An attempt was made to correct this determination by the following experiment:

Experiment 18.

Solution containing 10 cc trimethylamin hydrochlorid (dilute solution, strength unknown); 10 cc N/2 NH_4OH solution; 5 cc alcoholic soda (Kissling).

Absorbed with powdered magnesium carbonate.

Extracted with ether for upward of three hours. Ether was evaporated slowly, residue taken up with 50 cc N/10 NaOH.

Distilled 400 cc (with current of steam) into 20 cc N/2 HCl.

Titrated back with N/10 NaOH.

20 cc N/2 HCl are equivalent to	100 cc N/10 NaOH
Distillate equivalent to	98 cc
Volatile alkali is equivalent to	2 cc

2 cc N/10 are equivalent to 0.4 cc N/2 HCl.
2 cc N/10 are equivalent to 0.0324 gram nicotin.

Correction for experiment 17	0.01620 gram nicotin
	.21384 gram nicotin
Corrected	0.19764 gram nicotin, or

106.55 per cent nicotin were apparently recovered. This indicates a serious defect in the method at this point.

Attempts were now made to eliminate the bases other than nicotin by decomposing them. Nitrous acid does not, strange to say, form a nitroso compound with nicotin, in spite of the generally accepted constitutional formula assigned to that compound. Primary amins should be removed by decomposition and elimination of their nitrogen. Secondary amins should yield easily separated nitroso compounds, and by boiling in neutral solutions the ammonia should decompose entirely into nitrogen and water. A large number of careful experiments was tried with these objects in view. The results were disappointing. Tobacco extracts were found to contain relatively large proportions of trimethylamin, and this being a tertiary amin was unaffected by nitrous acid. Ammonium nitrite was found to decompose on boiling at a surprisingly slow rate. After four hours boiling the solution was found to contain a large percentage of undecomposed ammonia. This is now the subject of an independent investigation. Finally the following experiments will show that the process was not without effect on the nicotin itself. A blank was run first.

Experiment 19.

To 10 grams $NaNO_2$, added 30 cc H_2SO_4 (3 N?).

Slowly heated to boiling. Boiled until all acid fumes were removed. Made alkaline with NaOH solution and distilled into water colored with cochineal. Very slight evidence of alkaline reaction.

Experiment 20.

Started with solution containing 0.365 gram nicotin.
Added 20 cc N/2 H_2SO_4.
Added 5 grams $NaNO_2$.
Allowed to stand one hour in cold with occasional shaking.
Added 50 cc alkali [1.723 cc alk. = 1 cc N/2 acid.]
Distilled with steam until about 300 cc had come over, distilling into 30 cc N/2 H_2SO_4.

30 cc N/2 H_2SO_4 equivalent to	51.69 cc alkali
Distillate equivalent to	44.50 cc alkali
Nicotin equivalent to	7.19 cc alkali

7.19 cc alkali are equivalent to 4.17 cc N/2 H_2SO_4.
7.19 cc alkali are equivalent to 0.3377 gram nicotin.
92.5 per cent nicotin were recovered.

Experiment 21.

Started with solution containing nicotin 0.3547 gram.
Added 20 cc N/2 H_2SO_4.
About 5 grams $NaNO_3$.
Stood one hour.
Made alkaline with 50 cc NaOH solution [1.723 cc alk. = 1 cc N/2 acid.]
Distilled with steam (until about 300 cc came over) into 30 cc N/2 H_2SO_4.

30 cc acid equivalent to	51.69 cc alkali
30 cc acid and nicotin equivalent to	45.90 cc alkali
Nicotin equivalent to	5.79 cc alkali

5.79 cc alkali are equivalent to 3.36 cc N/2 H_2SO_4.
5.79 cc alkali are equivalent to 0.2722 gram nicotin.
76.7 per cent nicotin recovered.

Experiment 22.

Started with solution containing nicotin 0.7171 gram.
Added 18 cc acid N/2 H_2SO_4.
Added 10 grams $NaNO_2$ and allowed to stand over night.
Made alkaline with 50 cc soda solution, [1.723 alk. = 1 cc N/2 acid.]
Distilled 800 cc into flask containing 60 cc N/2 H_2SO_4.

60 cc N/2 H_2SO_4 equivalent to	103.38 cc alkali
60 cc N/2 H_2SO_4 and nicotin equivalent to	89.50 cc alkali
Nicotin equivalent to	13.88 cc alkali

13.88 cc alkali equivalent to 8.03 cc N/2 H_2SO_4.
13.88 cc alkali equivalent to 0.6521 gram nicotin.
90.93 per cent nicotin were recovered.
Continued distillation, 400 cc into flask containing 10 cc N/2 H_2SO_4.

10 cc N/2 H_2SO_4 equivalent to	17.23 cc alkali
10 cc N/2 H_2SO_4 and nicotin equivalent to	17.23 cc alkali

No nicotin in distillate.

Apparently the nicotin is oxidized more or less, depending on the conditions. The attempt was made next to get rid of the ammonia, etc., by treatment with sodium hypobromite and calcium hypochlorite, but decomposition of the nicotin made further attempts to apply the method useless. Further, the necessity of working in alkaline solutions made a large error by loss of nicotin very probable. It was not possible, of course, to acidify the solutions for the purpose of transferring them, etc., in view of the experiment with bromin, referred to above.

Ammonium oxalate is insoluble in alcohol, and comparatively so in aqueous alcohol, if the relative amount of water present be not large. Nicotin oxalate and the oxalates of organic bases generally are quite soluble. In order to test this as a method of separation, the solubility of the ammonium oxalate was determined in the following experiments:

Experiment 23.

Solution of ammonium oxalate in 99 per cent alcohol.

Saturated solution of ammonium oxalate in alcohol at 17.5° C	79.6365 grams
Evaporated, residue weighed	9.0097 grams
Solvent weighed	79.6348 grams

Equivalent to 0.0169 gram ammonium oxalate in a liter, or 1 part ammonium oxalate is soluble in 46,844 parts 99 per cent alcohol at 17.5° C.

Experiment 24.

Solution of ammonium oxalate in 78 per cent alcohol.

Saturated solution at 18.50 weighed	79.2150 grams
Evaporated, residue weighed	0.0177 gram
Solvent weighed	79.1973 grams

Equivalent to 0.18 gram in 1 liter, or 1 part ammonium oxalate is soluble in 4,475 parts 78 per cent alcohol. In view of these results the attempt was next made to separate ammonia from nicotin, with the following results:

Took solution of nicotin in water equivalent to 12 cc N/2 HCl.
Took solution of ammonia equivalent to 8 cc. Volume of mixture about 35 cc.
Added 98 per cent alcohol, about 350 cc, and a saturated solution of oxalic acid in alcohol until marked acid reaction. The whole was then cooled with ice water,

being shaken from time to time. The ammonium oxalate formed was then separated by filtration, with aid of the pump, and washed with 98 per cent alcohol. The filtrate and washings were then evaporated to small volume, the residue made up to about 400 cc with water, the solution made slightly alkaline and distilled in a current of steam. The distillate required 11.82 cc N/2 HCl to neutralize, or 98.5 per cent nicotin were recovered. This experiment was repeated. Distillate required, 11.9 cc N/2 HCl to neutralize it, or 99.1 per cent nicotin were recovered.

Estimation of nicotin in a tobacco extract which also contained much ammonia:

	Per cent.
By treatment with sodium nitrite	14.60
By treatment with sodium nitrite	18.44
By treatment with sodium nitrite	9.66
By treatment with sodium nitrite	10.64
By treatment with sodium nitrite	8.57
By treatment with sodium nitrite	17.88
By Kissling	13.59
By Kissling	12.46
Separation of ammonia as oxalate	5.95
Separation of ammonia as oxalate	6.00

The following conclusions seem warranted by the facts just presented:

I. Up to the present time no reliable method for the separation of nicotin from ammonia and other organic bases by precipitation has been suggested.

II. A complete extraction of nicotin by ether and some other solvents is readily accomplished.

III. An evaporation of an ether extract affords a practicable separation from ammonia alone, but not from other organic bases.

IV. In a separation by distillation with a current of steam, it is preferable to keep the volume in the distillation flask approximately constant. Much larger distillate is required in order to effect a complete separation than is usually supposed.

V. No method of separation by decomposition of accompanying bodies has been found practicable.

VI. A separation of nicotin from ammonia by means of alcoholic oxalic acid can be effectively accomplished.

VII. The presence of tertiary amins, and possibly some pyridin derivatives in tobacco extracts, is as yet an insurmountable difficulty in the separation or estimation of nicotin.

Professor Winton also reported the following modification of the Kissling method:

A METHOD WITHOUT EXTRACTION.

I devised this method with the idea that for commercial purposes Kissling's process, in the case of extracts, could be considerably shortened. The details are as follows: From 1 to 5 grams of the extract are weighed into a 400 cc flask having a mouth 3 cm in diameter. If the solution be so thick as not to flow easily it is diluted with 1 cc of water. One cc of a merely saturated solution of caustic soda is then added and by gentle agitation mixed as completely as possible with the extract. The following experiments indicate that all the ammonia is removed after standing without corking at the room temperature for twenty-four hours. Two 1 cc portions of 30 per cent ammonia treated by this process with 1 cc of soda yielded after standing twenty-four hours, on distillation with 50 cc N/10 caustic soda, distillates which neutralized respectively 0.15 and 0.20 cc N/10 sulphuric acid. A solution of pure nicotin gave by this method 12.66 per cent and 13.17 per cent nicotin, while a weighed portion of the same solution mixed with 1 cc 30 per cent ammonia gave 12.91 per cent. In the table are given results after standing with the strong soda, 24, 48, 72 and 100 hours, which show a loss from day to day, due probably to volatilization of nicotin. After the first twenty-four hours the loss was inconsiderable (about 0.5 per cent for each twenty-four hours) considering the errors incident to titration.

Notwithstanding this loss, the results after standing with the strong soda twenty-four hours are somewhat higher than by the Kissling method. This may be due in part to incomplete removal of ammonia, but I am convinced that this excess consists chiefly of pyridin bases or some other difficultly volatile alkaline substances.

Perhaps the experiments which I have cited to show that ammonia is completely driven off from a solution by treatment with strong soda for twenty-four hours may not prove the point. Ammonia water and soda mix perfectly, whereas a solution of nicotin, when treated with soda, at once separates into an oily nicotin layer, which floats, and an aqueous solution. This separation may prevent perfect contact of the soda with the ammoniacal solution, or the nicotin layer may interfere with the volatilization of the alkali. I think, however, that the results indicate that the ammonia is removed and that the whole trouble with both the Kissling method and the method without extraction is that pyridin bases are present in the nicotin distillate, the quantity being greater in the latter case. As the pyridin bases are most of them rank poisons, it may be urged with reason that the value of tobacco extracts does not depend entirely on the nicotin, and therefore a conventional method should be employed which, like the above, includes with the nicotin the largest amount of other poisonous bases.

The results of all the work that has been done show very clearly that more accurate methods should be secured for the determination of nicotin in tobacco. The tobacco dips are of very great importance and usefulness in the treatment of sheep for scab. When these tobacco dips are used for this purpose it is important to note what percentage of nicotin is present in the solution used in order to be sure that there is sufficient quantity to have the desired effect, and at the same time not too large an amount to injure the animal. I would suggest, therefore, that a committee or reporter be appointed by the association in order to see if some method can be devised which shall be considered as thoroughly standard and reliable as methods in other lines of work which have been adopted and approved by the Association of Official Agricultural Chemists.

At the conclusion of the reading of the paper it was voted that a referee and associate referee be appointed on insecticides, to which the matters left in doubt as indicated in the above paper should be referred.

The president then called upon Mr. E. W. Allen for the report of the abstract committee, which was presented, as follows:

REPORT OF THE COMMITTEE ON ABSTRACTS.

Mr. President and Members of the Association: Your committee has the honor to report that its work during the past year has been conducted on the same general plan as in previous years. Immediately after the appointment of the members of the committee correspondence was instituted to ascertain what journals were accessible to each member. Following this an assignment of the journals was made to the individual members, with a view to distributing the work as evenly as circumstances would permit. The following is a copy of the letter sent to each member of the committee, indicating the assignment of journals and making suggestions for the work:

November 23, 1897.

——— ———,
——— ———.

Dear Sir: The following is a list of the periodicals assigned to the different members of the abstract committee for 1897–98:

E. W. Allen: Forsch. Ber. Lebensmtl.; Ztschr. Nahr. Untersuch. u. Hyg.; abstracts in Analyst, Chem. Centbl., and Chem. Ztg. Repert.

J. T. Anderson: Chem. Ztg.; Jour. prakt. Chem.; Amer. Jour. Sci.

W. H. Beal: Bul. Soc. Chim. Paris; Compt. Rend. Acad. Sci. Paris; Forsch. Geb. Agr. Phys.; Ztschr. anorgan. Chem.; abstracts in Jour. Chem. Soc. [London].

B. H. Hite: Chem. News; Bul. Assn. Belge. Chim.; Jour. Pharm. et Chim.

J. B. Lindsey: Ztschr. angew. Chem.; Ztschr. physiol. Chem.; Jour. Landw.

L. H. Merrill: Ztschr. analyt. Chem.; Jour. Chem. Soc. [London]; Analyst.

A. A. Persons: Jour. Amer. Chem. Soc.; Rev. Chim. Analyt. et Appl.

J. P. Street: Amer. Chem. Jour.; Jour. Soc. Chem. Ind.; Landw. Vers. Stat.; Ber. deut. chem. Gesell.

F. W. Woll: Scandinavian periodicals; Milch Ztg.; Neue Ztschr. Rübenz. Ind.

It will be understood that this committee undertakes to abstract only articles relating to methods and apparatus for agricultural analysis. In this field it is very desirable that everything contained in the journals assigned should be either abstracted or listed by title, with a few words of explanation, according to the importance of the article. In case you do not desire to become responsible for all of the journals assigned to you will you please notify the chairman at once, so that other arrangements may be made. The Office of Experiment Stations desires to make the review of methods of agricultural analysis as complete as possible, and to that end will, as heretofore, supplement the work of the abstract committee.

It has been thought best to have the work of the new committee begin with journals issued on or after October 15, 1897. For the form of statement of the abstract reference is made to Experiment Station Record. In giving the reference please state the name of the periodical, using the abbreviations given above, the volume number in figures, the year in parentheses, the number within the volume (No., Heft, Fasc., etc), and the pages (beginning and end of the article) with the number of figures. The length of the abstract should be governed by the importance and value of the article, so far as practicable. Articles not deemed worthy of abstracting should be listed by title; usually a few words of explanation of the nature of the article may be added with advantage. Abstract only the original papers in the journals assigned, as the abstracts, where the journals contain such, are provided for. Please take pains to give full references and to write all names and technical terms plainly. The abstracts should be signed by the abstractor.

Both on account of the increased value and the convenience in publishing the abstracts, it is desirable that the work should be kept well up to date and not allowed to accumulate. There is necessarily considerable delay in publishing the Experiment Station Record, as is the case with most Government publications.

I send you herewith a supply of franked envelopes to be used in sending in material. Others can be procured as needed.

Very respectfully, yours,

E. W. ALLEN, *Chairman.*

The publication of the abstracts made by the new committee began in Experiment Station Record, Vol. IX, No. 4, and has continued quite regularly through the year up to Vol. X, No. 3, which is now in press. The printed work of the committee occupies about 60 pages. The effort has been to confine the work more strictly than heretofore to methods and apparatus for agricultural analysis in a broad sense.

Two of the members of the committee were obliged to withdraw from the work early in the year before scarcely anything had been done, and in some individual cases it has not been possible to keep the abstracting up to date. In such cases the attempt has been made to so supplement the work in the Office of Experiment Stations, that the abstracting of the journals would not be allowed to fall behind to any considerable extent. It is believed that in most lines the field has been covered in a general way and that the work is quite well up to date.

E. W. ALLEN,
J. T. ANDERSON,
W. H. BEAL,
B. H. HITE,
J. B. LINDSEY,
L. H. MERRILL,
A. A. PERSONS,
J. P. STREET,
F. W. WOLL,
Committee.

The report of the committee on food standards was next called for, and read by Mr. William Frear, as follows:

REPORT OF THE COMMITTEE ON FOOD STANDARDS.

STANDARDS.

At the session of 1897 this association appointed Messrs. H. W. Wiley, E. H. Jenkins, M. A. Scovell, H. A. Weber, and William Frear as a committee on food standards to consider the practicability of compiling, for the use of the increasing proportion of the association's membership charged with the duty of official food control, all accessible and trustworthy chemical and physical data as to the composition of foods and drinks for man and domestic animals offered for sale on the American market. This committee was authorized to initiate, without further action by the association, any such work as it might deem practicable and useful.

Your committee presents herewith, as a report of progress, the following statements:

Your committee, as the result of personal conference and correspondence, was unanimously of the opinion that European standards were not universally applicable to American food stuffs, and that the chemical methods employed by food analysts in other countries to determine the purity or the character of adulteration of foods were not always to be relied upon by American analysts, for the reason that in this country processes of food manufacture and adulteration are in vogue different, in many instances, from those practiced elsewhere.

The desirability of the compilation of authoritative data which might serve to the food analyst and manufacturer the same purpose as that portion of the United States Pharmacopœia relating to the composition and purity of drugs serves to the pharmacist was recognized, and it was deemed important that such compilation should be begun without further delay. The attempt to formulate a set of standards, except upon the basis of such a compilation, is regarded as premature and likely to cause confusion, though already accessible data make possible, for most of the important foods, the early formulation of a set of provisional standards.

Your committee, therefore, decided to organize at once the work of compiling from the best selected sources the following data:

1. The maximum, minimum, and average proportion of the most characteristic components in normal food substances, which in kind and proportion best serve to show the source of the product and which, in samples of unknown origin, best show whether they are pure or have been in any way tampered with.
2. The variations in these proportions due to differences in origin or treatment, as place of growth, stage of development, method of manufacture, etc.
3. Data showing the maxima for injurious constituents that occur naturally in food products, and indicating the maximum limits beyond which such substances, introduced incidentally during manufacture or to serve as preservatives, coloring agents, etc., can not be allowed to pass without menace to the health of the consumer.

For the better prosecution of this work the cooperation of the leading food chemists of America and foreign countries was invited.

The preliminary organization of the work consisted in the appointment of three subcommittees.

(A) To formulate rules to govern the selection of data, fix upon forms for their arrangement, and establish regulations needful for the bibliographic completeness of the work, so that the critical character of the work may be maintained, that it may itself invite intelligent criticism, and that the interpretation of data may be simplified, so far as possible. Also, to classify the subject-matter so that it may be satisfactorily subdivided and assigned to several editors and subeditors. Subcommittee: Messrs. Frear, Scovell, and Wiley.

(B) To prepare for the use of the committee a complete directory of official food chemists—national, State, and municipal, American and foreign. Subcommittee: Messrs. Weber, Jenkins, and Wiley.

(C) To prepare an analytical digest of existing food legislation: Messrs. Jenkins, Scovell, and Wiley.

Subcommittee A having recommended a classification of the entire subject-matter of foods and drinks, referees or editors were appointed, as follows, to work upon the compilation of analytical data and recommend, after consultation with all trade interests directly affected, suitable definitions and standards for the several food substances:

I. ANIMAL PRODUCTS:

A. *Meat*—
- (a) Raw, canned, pickled, salted, smoked, sausage.
- (b) Meat extracts, peptones, etc.
- (c) Lard.
- (d) Eggs.

Referee, Dr. Charles D. Woods, director, Maine Agricultural Experiment Station, Orono, Me.

B. *Milk and its products*—
- (a) Milk, skim milk, cream, butter, buttermilk, cheese, whey, koumiss, condensed, sterilized, pasteurized, conserved milk.
- (b) Ice cream and ices.
- (c) Infant foods.
- (d) Butter substitutes and cheese substitutes.

Referee, Dr. L. L. Van Slyke, chemist, New York Agricultural Experiment Station, Geneva, N. Y.

II. VEGETABLE PRODUCTS:

C. *Grains and their products*—
- (a) Cereals and legumes. Flour. Prepared meals and starches.
- (b) Bread and pastry, puddings, etc.
- (c) Cattle foods.

Referee, Dr. J. B. Lindsey, chemist, Massachusetts Agricultural Experiment Station, Amherst, Mass.

D. *Fruit and vegetables*—Dried, canned, preserved, fruit butters, jams, etc.

Referee, Prof. H. A. Weber, chemist to Dairy and Food Commissioner, Columbus, Ohio.

E. *Sugar and related substances*—
- (a) Sugar, molasses, sirups—cane, sorghum, maple, refinery, glucose, etc.—solid glucose.
- (b) Confectionery.
- (c) Honey.
- (d) Other sweetening agents.

Referee, Prof. M. A. Scovell, director, Kentucky Agricultural Experiment Station, Lexington, Ky.

F. *Condiments (except vinegar)*—
- (a) Spices.
- (b) Fruit extracts and artificial flavors.
- (c) Salad oils.
- (d) Salt.

Referee, Dr. A. L. Winton, chemist, Connecticut Agricultural Experiment Station, New Haven, Conn.

G. *Drinks and vinegar*—
- (a) Infusions—tea, coffee, cocoa, chocolate, cereals.
- (b) Fruit juices, fresh and sweetened. Fermented fruit juices—cider, perry, wine.
- (c) Vinegar.
- (d) Mead, root beer, etc.
- (e) Malted liquors.
- (f) Spirituous liquors.
- (g) Carbonated and other similar beverages.

Referee, Dr. Charles A. Crampton, chemist, Bureau of Internal Revenue, Washington, D. C.

H. *Substances artificially introduced with possible injury to health*—
- (a) Preservatives.
- (b) Coloring matters.
- (c) Metals and metallic salts.
- (d) Other injurious substances

Referee, Prof. H. A. Huston, State chemist of Indiana, Lafayette, Ind.

Subcommittee also submitted to the several editors a statement relative to the selection of data, the form in which they should be recorded with highest value for reference and critical examination, and to the principles of formulation of standards approved by the committee. Full consultation with all trade interests concerned was especially requested in the framing of definitions and formulation of standards.

Owing to the magnitude of this work it is not possible as yet for the editors to announce the full organization of their respective divisions of the work.

The committee may, however, announce that it is already in receipt of a most valuable compilation of existing data relative to the composition of American and European salad oils, by Prof. G. E. Colby, of the University of California; that Prof. F. W. Woll, of the University of Wisconsin, is now engaged upon an extensive study of table and dairy salts upon which, together with previously existing data, he hopes to offer recommendations; also, that Mr. A. L. Winton, owing to the dearth of American analyses of spices imported into this country, has, through the courtesy of a number of New York and Boston importers, sampled in original package more than 100 lots of the various spice materials and is now engaged upon their chemical and microscopic examination. The stimulation and suggestion of new and important lines of food investigation indeed promise to be of the most important results of the labors of the committee.

It is with pleasure that the committee notes the cordial cooperation of many of the leading manufacturers of the country in assisting the several referees in their laborious task.

In closing, your attention is called to the action of the National Pure Food and Drug Congress, that met in this city on March 3 to 5 last, composed of delegates represesenting most of the food trade, health and food control interests of America. This congress distinctly approved the enactment of a law establishing a commission to be composed of representatives appointed by the Association of Official Agricultural Chemists, together with others appointed by the American Chemical Society and of physicians, to be appointed by the President of the United States from the Surgeon-General's bureaus of the War and Navy Departments; which commission shall, upon request from the Secretary of Agriculture, and after due hearing of all trade interests, recommend to the Secretary of Agriculture, for use in United States courts, standards for such food substances as he may name.

In view of the general demand for the prosecution of the work intrusted to your committee and of the laborious nature of the tasks assumed by the several editors and subeditors, the committee bespeaks for each of them the most cordial cooperation of every member of the association.

H. W. Wiley, *Chairman.*
H. A. Weber.
M. A. Scovell.
E. H. Jenkins.
William Frear.

The report of the committee on food standards was adopted, and it was voted that the committee be continued for the purpose of completing the work.

Mr. H. J. Wheeler then read the following report of the committee on uniform methods of fertilizer control:

REPORT OF COMMITTEE ON UNIFORM METHODS OF FERTILIZER CONTROL.

STATEMENT OF PRINCIPLES.

(1) All substances containing nitrogen, potash, or phosphoric acid sold, offered, or exposed for sale for manurial purposes, excepting the dung of domestic animals when sold as such, should be subjected to inspection.

(2) Each package of manurial substance as above defined sold, offered, or exposed for sale should bear a printed, legible guaranty.

(3) The number of net pounds in each package should be stated.

(4) Each package should bear the brand, name, or trade-mark, and the name and address of the manufacturer.

(5) The quantities of manurial ingredients should be expressed in percentages.

(6) The guaranteed statements on the packages or forwarded to the inspectors need not be in the form of an affidavit.

(7) Sealed samples of fertilizers offered for sale need not be sent by the manufacturers to the inspectors.

(8) In lots of 5 tons or less samples should be drawn from at least 10 packages, or if less than 10 packages are present all should be sampled; in lots of over 5 tons not less than 20 packages should be sampled.

(9) Duplicate samples should be drawn and sealed in the presence of the party or parties in interest or their representatives, one of the samples to be taken by the collector and the other left with the party whose goods were inspected, subject to the call of the manufacturer.

(10) Total nitrogen should be guaranteed in all cases, and nitrogen in the form of nitrates or of ammonium salts should be guaranteed separately if the manufacturer desires credit therefor.

(11) Total phosphoric acid should be guaranteed in all cases, and soluble reverted and insoluble, separately, if the manufacturer desires credit therefor.

(12) Potassium should be guaranteed as potash (potassium oxid) soluble in water.

(13) When chlorin is present in fertilizers, manufacturers shall guarantee the maximum percentage thereof.

(14) Only statements of the minimum amount of the substances present, except in the case of chlorin, should be made. For example, instead of guaranteeing from 2 to 4 per cent of potash guaranties should read thus: 2 per cent of potash.

(15) It should be specified that the methods of the Association of Official Agricultural Chemists should be used for official work.

(16) An imprisonment clause for violation of fertilizer laws should be omitted.

(17) Manufacturers should not be obliged to secure bondsmen.

(18) Commercial valuations should not be affixed to the published analyses of manurial substances.

(19) A definition of the term "brand" should be inserted wherever a brand tax is assessed.

(20) The guaranty should state the ingredients guaranteed, in the following form and order:

Per cent phosphoric acid soluble in water.
Per cent phosphoric acid reverted.
Per cent phosphoric acid insoluble.
Per cent phosphoric acid total.
Per cent nitrogen in nitrates.
Per cent nitrogen as ammonia.
Per cent nitrogen total.
Per cent potash soluble in water.
Per cent chlorin.

Ingredients not present should be omitted from the guaranty and no other form of statement should be interpolated.

It is further recommended that this committee be continued as a standing committee on fertilizer legislation.

H. W. WILEY, *Chairman.*
B. W. KILGORE.
H. B. MCDONNELL.
H. A. HUSTON.
B. B. ROSS.

The committee appointed by the Association of American Agricultural Colleges and Experiment Stations to confer with the committee from the Association of Official Agricultural Chemists on uniformity in fertilizer laws, concurs with the committee in recommending the adoption of the above report as a guide which should be followed by the several States in the enactment of fertilizer laws and by the Congress of the United States should a law regulating interstate traffic in commercial fertilizers be enacted. H. J. Wheeler, Chairman; H. P. Armsby, E. H. Jenkins, M. A. Scovell, C. D. Woods, committee.

The thanks of the association were given to the Secretary of Agriculture, the retiring president, the secretary of the association, the Cosmos Club, and President Whitman and Dean Munroe of the Columbia University.

The convention adjourned at 1 p. m., to meet at time and place to be selected by the executive committee.

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Mr. H. W. **WILEY**, Washington, D. C.

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Mr. B. B. **ROSS**, Auburn, Ala.
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Liquor and food adulteration.—Mr. H. A. Weber, Columbus, Ohio.
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Nitrogen.—Mr. W. R. Perkins, Agricultural College, Miss.
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Soils and ash.—Mr. M. E. Jaffa, Berkeley, Cal.
Dairy products.—Mr. F. W. Woll, Madison, Wis.
Foods and feeding stuffs.—Mr. C. A. Browne, jr., State College, Pa.
Liquor and food adulteration.—Mr. W. D. Bigelow, Washington, D. C.
Sugar.—Mr. G. L. Spencer, Washington, D. C.
Tannin.—Mr. E. J. Haley.
Insecticides.—Mr. L. A. Voorhees, New Brunswick, N. J.

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Mr. M. A. Scovell, Lexington, Ky.
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Mr. Wm. Frear, State College, Pa.

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COMMITTEE ON REWRITING METHODS OF SOIL ANALYSIS.

Mr. M. A. Scovell, Lexington, Ky., chairman.
Mr. A. M. Peter, Lexington, Ky.
Mr. H. W. Wiley, Washington, D. C.

COMMITTEE ON REWRITING BULLETIN NO. 46.

Mr. H. W. Wiley, chairman, with associates to be selected by him.

CONSTITUTION OF THE ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS.

(1) This association shall be known as the Association of Official Agricultural Chemists of the United States. The objects of the association shall be (1) to secure uniformity and accuracy in the methods, results, and modes of statements of analysis of fertilizers, soils, cattle foods, dairy products, and other materials connected with agricultural industry; (2) to afford opportunity for the discussion of matters of interest to agricultural chemists.

(2) Analytical chemists connected with the United States Department of Agriculture, or with any State or national agricultural experiment station or agricultural college, or with any State or national institution or body charged with official control of the materials named in section 1, shall alone be eligible to membership; and one such representative for each of these institutions or boards, when properly accredited, shall be entitled to enter motions or vote in the association. Only such chemists as are connected with institutions exercising official fertilizer control shall vote on questions involving methods of analyzing fertilizers. Any person eligible to membership may become a member at any meeting of the association by presenting proper credentials and signing this constitution. All members of the association who lose their right to such membership by retiring from positions indicated as requisite for membership shall be entitled to become honorary members and to have all privileges of membership save the right to hold office and vote. All analytical chemists and others interested in the objects of the association may attend its meetings and take part in its discussions, but shall not be entitled to enter motions or vote.

(3) The officers of the association shall consist of a president, a vice-president, and a secretary, who shall also act as treasurer; and these officers, together with two other members to be elected by the association, shall constitute the executive committee. When any officer ceases to be a member by reason of withdrawing from a department or board whose members are eligible to membership his office shall be considered vacant, and a successor may be appointed by the executive committee, to continue in office till the annual meeting next following.

(4) There shall be appointed by the president, at the regular annual meeting, a referee and associate referee for each of the subjects to be considered by the association.

It shall be the duty of these referees to prepare and distribute samples and standard reagents to members of the association and others desiring the same; to furnish blanks for tabulating analyses, and to present at the annual meeting the results of work done, discussion thereof, and recommendations of methods to be followed.

(5) The special duties of the officers of the association shall be further defined, when necessary, by the executive committee.

(6) The annual meeting of this association shall be held at such place as shall be decided by the association, and at such time as shall be decided by the executive committee, and announced at least three months before the time of meeting.

(7) No changes shall be made in the methods of fertilizer analyses, except by unanimous consent, until an opportunity shall have been given all official chemists having charge of fertilizer work to test the proposed changes.

(8) Special meetings shall be called by the executive committee when in its judgment it shall be necessary, or on the written request of five members; and at any meeting, regular or special, seven enrolled members entitled to vote shall constitute a quorum for the transaction of business.

(9) The executive committee will confer with the official boards represented with reference to the payment of expenses connected with the meetings and publication of the proceedings of the association.

(10) All proposed alterations or amendments to this constitution shall be referred to a select committee of three at a regular meeting, and after report from such committee may be adopted by the approval of two-thirds of the members present entitled to vote.

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BULLETIN No. 57.

U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF CHEMISTRY.

PROCEEDINGS

OF THE

SIXTEENTH ANNUAL CONVENTION

OF THE

ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS

HELD AT

SAN FRANCISCO, CAL.,

JULY 5, 6, AND 7, 1899.

EDITED BY

HARVEY W. WILEY,
SECRETARY OF THE ASSOCIATION.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1899.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Division of Chemistry,
Washington, D. C., October 19, 1899.

Sir: I have the honor to transmit to you herewith the manuscript of the proceedings of the sixteenth annual meeting of the Association of Official Agricultural Chemists, with the request that it be published as Bulletin No. 57 of the Division of Chemistry.

H. W. Wiley,
Chief of the Division of Chemistry and Secretary of the Association of Official Agricultural Chemists.

Hon. James Wilson,
Secretary of Agriculture.

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PROCEEDINGS OF THE SIXTEENTH ANNUAL CONVENTION OF THE ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS.

FIRST DAY'S PROCEEDINGS.

The sixteenth annual convention of the Association of Official Agricultural Chemists was held in San Francisco, Cal., beginning July 5, 1899. The meeting was called to order by the president, Mr. R. C. Kedzie, in the assembly hall of the Mills Building.

MEMBERS AND VISITORS PRESENT.

The following members and visitors were in attendance:

Allen, E. W., Office of Experiment Stations, Department of Agriculture, Washington, D. C.
Armsby, H. P., Agricultural Experiment Station, State College, Pa.
Bishop, R. Knight, Berkeley, Cal.
Blasdale, W. C., Agricultural Experiment Station, Berkeley, Cal.
Blouin, R. E., Agricultural Experiment Station, Audubon Park, La.
Burd, John S., Berkeley, Cal.
Buffum, B. C., Agricultural Experiment Station, Laramie, Wyo.
Chatfield, J. L., Gypsum, Colo.
Chilcott, E. C., Agricultural Experiment Station, Brookings, S. Dak.
Chesnut, V. K., Division of Botany, Department of Agriculture, Washington, D. C.
Cobb, N. A., Department of Agriculture, Sydney, New South Wales.
Colby, George E., Agricultural Experiment Station, Berkeley, Cal.
Cook, A. J., Claremont, Cal.
Curtis, Marvin, wine chemist with J. M. Curtis & Son.
Dyer, Hubert, Grand Junction, Colo.
Ellis, Frank F., Berkeley, Cal.
Frear, William, Agricultural Experiment Station, State College, Pa.
Goss, A., Agricultural Experiment Station, Mesilla Park, N. Mex.
Gould, Ralph A., San Francisco, Cal.
Hartwell, Burt L., Agricultural Experiment Station, Kingston, R. I.
Herff, B. von, German Kali Works, New York City.
Hills, J. L., Agricultural Experiment Station, Burlington, Vt.
Hite, B. H., Agricultural Experiment Station, Morgantown, W. Va.
Hutchinson, W. L., Agricultural Experiment Station, Agricultural College, Miss.
Jaffa, M. E., Agricultural Experiment Station, Berkeley, Cal.
Jenkins, E. H., Agricultural Experiment Station, New Haven, Conn.
Kedzie, R. C., Agricultural Experiment Station, Agricultural College, Mich.
Kilgore, B. W., Raleigh, N. C.
Lewers, Robert, Nevada State University, Reno, Nev.

Lloyd, E. R., Agricultural Experiment Station, Agricultural College, Miss.
McKellips, C. M., Agricultural Experiment Station, Corvallis, Oreg.
Miller, H. K., Agricultural Experiment Station, Lake City, Fla.
Muncy, V. E., Agricultural College of Kentucky, Lexington, Ky.
Myers, John A., 12 John street, New York City.
O'Brien, W. M., 1609 Oak street, San Francisco, Cal.
Patterson, Walter K., Agricultural Experiment Station, Lexington, Ky.
Redding, R. J., Agricultural Experiment Station, Experiment, Ga.
Rising, W. B., University of California, Berkeley, Cal.
Rosencrantz, A., San Francisco, Cal.
Rowley, B. N., 203 California street, San Francisco, Cal.
Runyan, E. G., Division of Chemistry, Department of Agriculture, Washington, D. C.
Scovell, M. A., Agricultural Experiment Station, Lexington, Ky.
Shaw, G. W., Agricultural Experiment Station, Corvallis, Oreg.
Smith, C. D., Agricultural Experiment Station, Agricultural College, Mich.
Snow, Frank J., Berkeley, Cal.
Stabler, H. P., Yuba City, Cal.
Stewart, J. H., Agricultural Experiment Station, Morgantown, W. Va.
Stockbridge, H. E., Agricultural Experiment Station, Lake City, Fla.
Thompkins, P. W., 123 California street, San Francisco, Cal.
Thompson, C. D., Corvallis, Oreg.
Tolman, L. M., Berkeley, Cal.
Traphagen, F. W., Agricultural Experiment Station, Bozeman, Mont.
Voorhees, Edward B., Agricultural Experiment Station, New Brunswick, N. J.
Wickson, E. J., Agricultural Experiment Station, Berkeley, Cal.
Wiley, H. W., Division of Chemistry, Department of Agriculture, Washington, D. C.
Williams, C. B., Agricultural Experiment Station, Raleigh, N. C.
Wilson, N. E., Agricultural Experiment Station, Reno, Nev.
Withers, W. A., Agricultural Experiment Station, Raleigh, N. C.
Withycombe, James, Corvallis, Oreg.
Woll, F. W., Agricultural Experiment Station, Madison, Wis.
Woods, Charles D., Agricultural Experiment Station, Orono, Me.
Wrampelmeier, T. J., Custom-house, San Francisco, Cal.

ORDER OF BUSINESS.

The executive committee reported the following order of business:
Reports of the referees in the following order:
First. Report on nitrogen.
Second. Report on potash.
Third. Report on phosphoric acid.
Fourth. Report on soils and ash.
Fifth. Report on foods and feed stuffs.
Sixth. Report on food adulteration.
Seventh. Report on dairy products.
Eighth. Report on sugars.
Ninth. Report on tannin.
Tenth. Report on nicotin.
Eleventh. Reports of special committees (abstract committee, food standards, uniform laws for fertilizer control, volumetric standards, rewriting methods of soil analysis), rewriting Bulletin 46.

PRESIDENT'S ADDRESS.[1]

MEMBERS OF THE ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS: Continued custom finally assumes the function of law, the unwritten law of society, more pervasive than formal statutes, and controlling social relations and conditions because arising spontaneously in the affairs of daily life. This unwritten law of custom demands an address from the presiding officer of this association. In former years papers of great value have been presented as presidential addresses on a variety of topics related to our special lines of work, such as the progress and methods of fertilizer analysis and control; the analysis of foods and fodders, the detection and prevention of adulterations in commercial articles of this class; standards of purity of materials for foods and articles related thereto, etc.

Such papers, presented before such a body of men, can not fail of having a large influence in improving the conditions of living in the wide constituencies of States and communities here represented.

When we consider the progress made and the work already accomplished in your special lines of work, and the advanced condition of analytical methods you have attained, as compared with those of fifteen years ago, we find large encouragement. Nor is the value of this progress recognized in this country alone. The fact that the Chemical News republished bodily your special methods of analysis shows the standing in which your methods are held by chemists in Europe.

The new apparatus and appliances here brought into use, such as the Gooch crucible, the Babcock method for analysis of milk, the electrical air bath for drying precipitates and other materials without danger of overheating or need of constant watching, the electric lamp for continuous and safe distillation in the extraction of fat by ether—these and similar appliances will do much to mitigate the drudgery, yet increase the accuracy of chemical analysis for the future. The need for more rapid methods without impairment of accuracy is a thought often present to your minds. To this end any new apparatus or application of known forces to new uses will be welcome. Forty-seven years ago Liebig pointed out the great importance of cork, glass, platinum, and caoutchouc for the advancement of chemistry. We may now with equal emphasis speak of electricity in its many phases and uses as contributing to the success of the masterful science. But to show how shortsighted is the foresight even of the most acute minds it is only necessary to recall the fact that in the same delightful Familiar Letters on Chemistry, Liebig pointed out the folly of making sugar from beets and illuminating gas from coal; and this less than fifty years ago.

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[1] Delivered before a joint meeting of the Association of Official Agricultural Chemists and the Association of Agricultural Colleges and Experiment Stations, held in the Academy of Sciences.

New environments call out new duties. Up to this year all the annual conventions of this association have been held in the region lying east of the Mississippi River, and usually in the National Capital. The special agricultural requirements of the Eastern section, the limiting conditions of crop production by peculiarities of soil and climate, the favoring conditions for special crops and productions in certain districts, the diverse interests and contrasted capacities of different sections—these and similar topics have filled your minds, guided your pens, and penetrated your laboratories and experimental grounds for final solution.

In the East the soil is very literally the bottom fact of all agricultural processes, and it is to the soil we have given our chief attention; its chemical composition and physical properties, the quality and availability of the plant food in the soil, how to increase these and yet prevent their loss by the sapping and mining of subsoil drainage and percolation, by which soluble salts are finally swept into the all-devouring sea—such are some of the agricultural problems of the East.

But we have entered a new environment. Most of you have reached the Pacific slope by crossing the several ranges of the Rocky Mountains, and have not failed to mark the contrast in the flora of the eastern and western slopes of these "vast dividing walls of climate," and their influence upon the vast basins that lie between them. The principal chains of the American Continent lie along its western border, and their general trend is north and south. Think for a moment how different would be the climatic conditions if the trend of these mountain chains were east and west, as in the Old World. Picture to your minds the change in the climate of the great basins of the Rockies under such conditions. No mountain chains more emphatically claim Dove's telling phrase, "dividing walls of climate," than the Andean chain stretching from Alaska to Cape Horn.

Whatever the physical causes, we find ourselves in the midst of many sharp contrasts with the conditions prevailing in the East. A witty friend in southern California described the contrast between the East and West thus: "In the East you sell the soil and the climate goes with the land; here we sell the water and climate and throw in the land." "Si quaeris mundum novum, circumspice."

Here is a new world, and the changed conditions of agriculture challenge your attention. I need not stop to point them out. California is an open book, and he who runs may read.

In regard to new work for the coming year I have little to suggest. The work now in hand seems to be in good shape, and I have no criticism to offer. Following in the steps of my illustrious predecessors, my suggestions are mainly in the line of detecting and exposing frauds and adulterations connected with food materials. The subject of butter comes prominently into view in my section, not solely the old evil of oleo compounds, but the disguising and manipulating for purposes of sale of what was once butter, but has survived the period of its usefulness; putting the putrid stuff through some process and selling the same as prime butter. The Michigan legislature has just enacted a law to prevent the sale of this "process butter" unless it bears a printed certificate of its real character. How to identify in the courts this "process butter," so as to throw the protecting arm of the law over genuine prime butter, is a subject for your consideration. That carload lots of such "shoe-box butter" is thus treated to be offered for sale as creamery butter is well known. Some may say that any treatment by which the rancid stuff may put on an appearance of respectability should be encouraged, and reform even in butter should be approved. Lord Brougham said "change is not reform." I quote the old maxim "Let every (butter) tub stand on its own bottom."

In a similar class may be placed such materials as "Lactobutu," to convert 10 pounds of rancid butter and 5 pounds of milk into 15 pounds of good butter, the material and information for $5. Some may say that a man who does not know that 5 pounds of milk can not be converted into 5 pounds of butter by any chemicals or manipulation ought to invest $5 to buy wisdom much needed. But in olden times, of ten virgins five were wise and five otherwise, and if observation is not misleading, the proportion of the first class in the human family has not largely increased in nineteen centuries.

Other items in the list of doubtful honesty are so-called stock foods, one especially represented as greatly excelling oil meal in value. These should generally be classed simply as condiments or condition powders so familiar to stockmen.

Wheat flour is so intimately related to the staff of life, and American flour is of such excellent quality and high reputation, both at home and abroad, that any adulteration of the material or smirching its reputation should call forth an indignant protest. The material is not only so good in quality but so abundant in our country that there should be no excuse for adulterating it. But the process was begun in a neighboring State and it spread so rapidly as to threaten to drive out honest milling from our land. The most common form of adulteration ("blending" as it was euphoniously called) was by mixing with wheat flour a quantity of white corn meal, corn starch ("flourine") or other products of Indian corn. The profits from incorporating the products of the cheaper grain with wheat flour were so large that the adulterated flour could be sold at a price much below pure wheat flour, yet leaving so large a margin of profit that genuine wheat flour was being driven out of its legitimate market. A miller at the head of a large milling concern in another State told the late W. A. Coombs, of Coldwater, Mich., that "by blending corn products with my wheat flour I make a cash profit of $600 a day, and why should I not do it?" A man who will ask that question will do it.

The Michigan millers were almost in despair. They could not sell flour in the Southern States except at a loss, and were being driven out of the Eastern States. There was even danger that such adulterated flour would be sent abroad, and when detected there the European markets would be closed against American flours as a class. The millers urged Congress to pass a law to prevent such mixed flours from being sold as wheat flour, and the Tawney bill was introduced to compel the marking of such flours as mixtures, and thus distinguishing them from genuine flour. But a powerful corn-fed lobby prevented such legislation till the Spanish war was upon us and the sinews of war must be obtained from every available source, when a small license fee was demanded and a small tax imposed, requiring a stamp upon every package of the mixed flour. When such a mark of Cain is placed upon a food material it becomes a fugitive and vagabond on the earth.

Another adulterant for wheat flour requires only a brief notice, for it can only be short-lived. This material is prepared and shipped in some quantity from Greensboro, N. C., under the name of Mineraline. It is nothing but ground rock of the feldspathic class, and its food value nil, yet the party making this stuff seems to find quite a market for it. A friend in Greensboro one year ago wrote me that this party held an order for 150 tons of Mineraline to be shipped to Tennessee to mix with flour, and was shipping car lots to northeastern cities for the same purpose.

In olden times the question arose "If a son ask his father for bread, will he give him a stone?" This question seems to have found an affirmative answer in North Carolina.

APPOINTMENT OF COMMITTEES.

The president appointed the following committee on recommendations of referees: Messrs. Woods, Scovell, Jenkins, Hutchinson, and Shaw.

Messrs. Frear, Woll, and Colby were appointed a committee on nominations.

Mr. Wiley. The reporters, or referees, have had very little time in which to prepare their material, and therefore the secretary of the association suggested that in the absence of ample data each one should give a short résumé of the evolution of the subject assigned him from the beginning of the association to the present time, so that we could have a historical account of what had really been accomplished in the way of codifying, unifying, and perfecting the methods employed in the investigation.

With the same object in view I have prepared a full history of the meetings before the present association was organized. I did this because the earlier reports are not available. The library of the Department of Agriculture itself does not possess them, and in order to prepare the data for this paper I was compelled to resort to the members who composed these earlier meetings, to whom I addressed circular letters. From many of them I received replies. I propose to incorporate in the report of this meeting the minutes of the meetings held in 1880 in Washington, and in Boston in the same year, and of the meetings held in Cincinnati in 1881 and in Atlanta in 1884. Thus the members of the present association will be able to have a complete record, in conjunction with the bulletins issued, of the progress this association has made during the period of nineteen years since the attempt was made to unify methods of research in agricultural chemistry.

Mr. Frear. In view of the method of discussion suggested to the several referees by the association, and of the conditions of this meeting, and in view of the fact that the secretary himself has prepared a résumé of the history of the work of the association in general, it occurs to me that it might be desirable to have this last-named paper read first, as a proper introduction of the discussion. I would therefore mo[illegible] that the secretary of the association be requested to read this historical sketch to open the work.

Mr. Wiley. Mr. President and Gentlemen: I will not read the whole of this paper, because it will be found in full in the report of the proceedings. The title of this paper is "Historical Sketch of the Association of Official Agricultural Chemists," and, preliminarily, I will say that I have prepared a list of those present at the Atlanta meeting in 1884, which was the precursor of the organization that is meeting here to-day. As perhaps it will be interesting I will read the names of those present at the Atlanta meeting:

Judge J. T. Henderson, Prof. H. W. Wiley, Prof. N. W. Lord, Dr. Charles W. Dabney, jr., Prof. William A. Noyes, Dr. Charles U. Shepard, jr., Dr. J. W. Gascoyne, Dr. Allard Memminger, Mr. Philip E. Chazal, Dr. E. H. Jenkins, Prof. S. W. Johnson, Prof. H. C. White, Dr. N. P. Pratt, Mr. G. W. Benson, Mr. N. A. Pratt, Prof. John A. Myers, Prof. J. A. Burns, Mr. L. H. Jones, jr., Mr. C. L. Allen, Mr. G. W. Davison, Prof. W. C. Stubbs, Dr. Arthur T. Neale, Mr. P. T. Pendleton, Mr. C. B. F. Lowe, Mr. Leroy Broun, jr., Mr. C. M. Strahan, Mr. A. F. Crowell, Mr. C. V. Petraeus, Mr. Theo. Schumann, Mr. P. J. Schumann.

Many of these names you will recognize as being those of men who have been most active in the work of the association since the Atlanta meeting.

The following is a list, arranged alphabetically, of official agricultural chemists, and others associated with them who have attended the several meetings since the organization of the association:

List of Members who have attended the Meetings of the Association of Official Agricultural Chemists, and the Numbers of the Meetings attended by Each.

Adriance, Duncan, 8.
Alexander, J. P., 12.
Allen, E. W., 7, 8, 9, 11, 13, 14, 15.
Allen, W. M., 13.
Alvord, Henry E., 7, 15.
Anderson, Cyrus N., 14.
Anderson, James T., 6, 7, 8, 9, 11, 12, 14.
Andrews, W. H., 14.
Armsby, H. P., 9, 13.
Atwater, B. M., 14.
Atwater, W. O., 6, 7, 10, 15.
Babcock, S. M., 4, 8, 9, 10.
Bartlett, J. M., 8, 11, 12, 14, 15.
Battle, H. B., 6, 7, 8, 13.
Beal, W. H., 9, 11, 12, 13, 14, 15.
Benjamin, Marcus, 12.
Bigelow, W. D., 9, 10, 11, 12, 13, 14, 15.
Black, S. E., 9.
Blair, A. W., 14.
Blouin, R. E., 10.
Bolton, H. Carrington, 14.
Bomberger, F. B., 12, 13.
Bond, Charles E., 4.
Bowman, Walker, 6, 7.
Broadbent, F. V., 2, 3, 4.
Bromwell, William, 11.
Brown, W. G., 12.
Bryant, A. P., 14.
Buckley, S. S., 13.
Burney, W. B., 6, 7.
Caldwell, G. C., 4, 6, 7, 8, 13.
Cameron, F. K., 14.
Cameron, George W., 14.
Carman, J. S., 11.
Carman, J. Y., 9.
Carpenter, F. B., 7, 8, 11, 13, 14, 15.
Carr, Oma, 11, 12, 13, 14, 15.
Cathcart, Charles S., 8, 9.
Chace, E., 9.
Chazal, Philip E., 1, 2, 3, 4, 5, 10.
Chesnut, V. K., 12, 13.
Chute, H. D., 11.
Clark, Reed Paige, 14.
Clarke, F. W., 2, 6, 8, 9, 13.
Coates, Charles B., jr., 14, 15.
Cochran, C. B., 10.
Collingwood, Charles B., 8, 10.
Cooke, W. W., 3, 7, 8.
Craighill, G. P., 14, 15.
Crampton, C. A., 2, 4, 5, 7, 8, 9, 10, 11, 12, 13, 14.
Crawley, J. T., 8.
Croxton, H. E., 12.
Curtis, H. E., 10, 13.
Cutter, W. P., 11, 12, 13, 14.
Dabney, Charles W., jr., 1, 2, 5, 8.
Dancy, F. B., 7.
Davidson, R. J., 8, 9, 11, 12, 13, 14.
Davis, I. T., 8.
Dickeson, William E., 14.
Doremus, C. A., 10.
Dorset, Marion, 12.
Dugan, John, 4, 5, 9, 12, 13.
Eaton, C. N., 10.
Edson, Hubert, 5, 7, 8.
Ellett, W. B., 14.
Elliott, J. C., 8
Englehardt, F. E., 6.
Ewell, E. E., 9, 10, 12, 13, 14, 15.
Fake, N. J., 4, 5.
Farrington, E. H., 4, 5, 7, 8, 10, 11.
Fellows, G. S., 3, 4, 6, 8, 9.
Fernandez-Cavada, Fernando, 14.
Finney, F. I., 11.
Fraps, G. S., 13.
Frear, William, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15.
Fries, J. A., 10, 12.
Fristoe, E. T., 8.
Fuelling, John L., 8, 11.
Fulmer, Elton, 14.
Gaines, R. H., 1, 5, 6, 7, 8, 10, 12, 13, 14, 15.
Gardner, F. D., 12.
Gascoyne, W. J., 2, 3, 4, 5, 6, 7, 8, 11, 15.
de Ghequier, C., 1, 2, 3, 4, 7.
Gibson, Charles B., 7.
Gladding, Thomas S., 2.
Goss, Arthur, 12, 13.
Green, Arthur L., 4.
Grindley, H. S., 14.
Hand, W. F., 14.

Hardee, R. E., 9.
Hardin, M. B., 9.
Harper, D. N., 8.
Harrington, H. H., 6, 8, 9.
Harris, A. W., 7, 8, 9.
Hartwell, B. L., 10 15.
Haywood, J. K., 14, 15.
Heavener, J. G., 12.
v. Herff, Rudolf, 7, 8, 9, 11, 12, 13.
Hills, J. L., 13, 14, 15.
Hiltner, R. S., 15.
Hird, J. D., 6, 13, 14.
Hite, B. H., 12, 13, 14, 15.
Holland, E. B., 15.
Holter, George L., 6.
Holton, Fred A., 4, 5, 9.
Horton, H. E., 7.
Huston, H. A., 7, 8, 9, 10, 11, 12, 13, 14, 15.
Hutchinson, P. L., 9.
Hutchinson, W. L., 5, 6, 9, 12.
Jaffa, M. E., 15.
Jenkins, E. H., 1, 2, 3, 4, 6, 8.
Jenter, C. G., 14.
Johnson, D. D., 8.
Johnson, S. W., 13.
Jones, Charles H., 14, 15.
Jordan, W. H., 8.
Kebler, L. F., 10.
Kedzie, F. S., 11.
Kedzie, R. C., 6, 7, 8, 9, 10, 12, 15.
Kepich, A., 11.
Kerr, G. A., 11, 15.
Kilgore, B.W., 6, 8, 9, 10, 11, 12, 13, 14, 15.
Knorr, A. E., 2, 3, 4, 5, 7, 8, 9.
Knox, Roy, 14.
Krug, W. H., 8, 9, 11, 12, 14, 15.
Krumbharr, Chas. Conrad, 14.
Langfeldt, Felix, 4.
Langworthy, C. F., 13, 14, 15.
Laughlin, J. R., 13, 14, 15.
Lehmann, A., 1, 3, 9.
Lehmann, G. W., 14.
Lindsey, J. B., 10, 11, 12, 13, 14.
Lord, N. W., 4, 8, 10.
Lupton, N. T., 3, 4, 6, 7, 8, 9.
McAdie, A. G., 8.
McCarty, R. Lee, 15.
McBryde, J. B., 6, 7.
McDonnell, C. C., 12.
McDonnell, H. B., 6, 7, 8, 9, 10, 11, 12, 13, 14, 15.
McDonnell, M. E., 11, 12.
McDowell, M. S., 12.
McElroy, K. P., 8, 9, 10, 11, 12.
McMurtrie, William, 3, 4.
Macfarlane, Thomas, 4.
Manns, A. G., 12.
Maxwell, Walter, 8.
Meng, Jas. S., 15.
Merrill, L. H., 12, 13.
Mitchell, A. S., 12.
Mitchell, G. A., 10.
Mitchell, W. L., 15.
Moore, C. C., 12, 13, 14, 15.
Morse, Fred W., 6, 8, 11, 12, 15.
Moses, W. E., 2, 3, 4.
Munroe, C. E., 14.
Myers, John A., 1, 3, 4, 5, 6, 7, 8, 12, 13, 15.
Nicholson, H. H., 6, 7, 8.
Nolan, W. P., 11.
North, J., 14.
Ogden, A. W., 8.
Palmer, T. Chadley, 15.
Parsons, Charles L., 7, 9, 10.
Patrick, George E., 8, 13, 14.
Patterson, H. J., 5, 6, 7, 8, 9, 11, 12, 13, 14, 15.
Patterson, L. G., 7, 8, 12.
Payne, George F., 8, 9, 10, 11, 12.
Peacock, S., 11, 12, 13, 14.
Peebles, A. B., 15.
Penny, C. L., 7, 8, 9, 12, 13, 14.
Perkins, George E., 14.
Perkins, W. R., 10, 11, 13.
Persons, A. A., 12, 14.
Peter, A. M., 9, 11, 12.
Price, W. B., 2.
Quick, W. J., 13.
Rawls, W. A., 10, 11, 12.
Richards, Edgar, 2, 3, 4, 5, 6, 7.
Richardson, Clifford, 1, 2, 3, 4, 5, 6, 7.
Rising, W. B., 4, 10.
Robinson, Norman, 6, 7, 8, 9.
Robinson, S. A., 8.
de Roode, Rudolf, 8, 9, 10, 11.
Rosell, C. A. O., 12.
Ross, B. B., 2, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15.
Runyan, E. G., 11, 12, 13, 14, 15.
Sanborn, T. F., 11, 12.
Saunders, W. M., 5.
Schulte, J. I., 15.
Schumann, Dr., 1.
de Schweinitz, E. A., 4, 5, 7, 8, 9, 10, 11, 13, 14, 15.
Scovell, M. A., 3, 4, 5, 6, 7, 8, 9, 10, 13, 14, 15.
Seal, Alfred N., 15.

Sederholm, E., 10.
Sharpless, S. P., 10.
Shepard, Jas. H., 8.
Sherman, H. C., 10, 11, 12.
Shiver, F. S., 7, 9.
Shutt, Frank T., 4, 10, 13.
Shuttleworth, A., 11.
Slosson, E. E., 10.
Skinner, W., 12, 13, 14, 15.
Smith, H. M., 10.
Snyder, Harry, 15.
Spencer, G. L., 9, 11, 14.
Steiger, G., 11.
Stewart, J. H., 15.
Stokes, H. N., 15.
Strahan, C. Morton, 6.
Street, J. P., 7, 8, 9, 10, 11, 12, 13, 14, 15.
Stubbs, William C., 2, 3, 4, 5, 7, 8, 10, 12.
Sutton, D. C., 8
Sweetser, W. S., 14.
Tassin, Wirt, 11, 12.
Teller, George L., 8, 10, 13.
Terne, Bruno, 6, 7, 8, 9, 11, 12.
Test, F. C., 11.
Thigpen, J. H., 14.
Trescot, T. C., 3, 7, 10, 12, 13, 14, 15.
Trubek, M., 10.
True, A. C., 15.
Van Slyke, L. L., 7, 8, 9, 10, 11, 12, 13, 14, 15.
Veitch, F. P., 11, 12, 13, 14, 15.
Voorhees, E. B., 5, 6, 7, 8, 9, 11.
Voorhees, Louis A., 8, 9, 10, 11, 15.
Wahl, R., 10.
Wainwright, J. H., 14.
Waite, C. E., 4.
Warder, Robert B., 4, 6.
Warrington, R., 8.
Watson, T., 11.
Wedderburn, Aug., 9.
Welty, Harry T., 14.
Westenfelder, B., 11, 12.
Wheeler, E. J., 14.
Wheeler, H. J., 8, 9, 11, 12, 13, 14, 15.
White, H. C., 1, 2, 3, 5.
Whitney, Milton, 4, 7, 9, 11, 12.
Wiley, H. W., 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15.
Williams, C. B., 13, 14, 15.
Williams, William J., 7, 8.
Wilkinson, L. W., 8.
Winton, A. L., 8, 9, 10, 11, 12, 13, 14, 15.
Withers, W. A., 8.
Wolff, Frank A., jr., 12.
Woll, F. W., 10, 11, 15.
Woods, Charles D., 7, 8, 9, 12, 15.
Yeates, W. S., 9.
Yocum, J. H., 11, 13, 14, 15.

HISTORICAL SKETCH OF THE ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS.

By H. W. Wiley.

The condition of agricultural chemical work in the United States in 1880 was a peculiar one. The few chemists who were engaged in agricultural research were acting in complete independence of each other in regard to methods of investigation and of research. Some of them were using the methods employed by German chemists, while others followed the instruction given by the French or English agricultural chemists. There was no unity of interest in the profession nor any common system of work. The condition of analytical work may be truly described as chaotic. The result of such condition is easily imagined. There was no standard of comparison or reference. Buyers and sellers were continually wrangling over analyses, which, made by different men following different methods, did not agree.

The sellers' chemists uniformly obtained higher results than the buyers', and thus the door to litigation was constantly open.

Strange as it may seem, the first steps toward correcting this pitiable condition did not come from the Department of Agriculture at

Washington, but from the department of agriculture of one of the States. It was through the Hon. J. T. Henderson, commissioner of agriculture of Georgia, and at the instigation of Mr. H. J. Redding, now director of the Georgia station, that the first step toward uniformity of action among agricultural chemists of the United States was taken.

The report of this initial meeting is of such interest as to warrant its reproduction in full in the proceedings of this association:

Convention of Agricultural Commissioners and Chemists at Washington, D. C.[1]

The following circulars will explain in brief the object of the convention:

DEPARTMENT OF AGRICULTURE,
Atlanta, Ga., May 20, 1880.

——— ———,
———, ———.

DEAR SIR: The experience of the last fertilizer season has suggested to my mind the importance of securing such uniformity of method in determining by chemical analysis the percentage of valuable ingredients in commercial fertilizers as will give more uniform and hence more satisfactory results. This is especially desirable in determining reverted phosphoric acid.

With a view to accomplishing so desirable an object, as well as others which may be deemed proper, I have the honor to suggest the calling of a convention of the several commissioners of agriculture, representatives from the State boards of agriculture, State chemists, and professors of chemistry in State universities and State agricultural colleges, in those States using large amounts of commercial fertilizers, to meet at some convenient point early in the month of July next.

I would be glad to have your views on the subject; and if favorable to the suggestion, please nominate some gentleman who, by general assent, may be informally authorized to fix the time and place of such convention and issue the necessary notices.

You are also requested to give me the names and post-offices of gentlemen in your State, holding either of the positions above indicated, which do not appear in the list below, that copies of this circular may be sent to them.

An early reply is desirable.

Very respectfully,
J. T. HENDERSON,
Commissioner of Agriculture.

DEPARTMENT OF AGRICULTURE,
Atlanta, Ga., July 1, 1880.

——— ———,
———, ———.

DEAR SIR: I am gratified to announce that the recent circular which I had the honor to issue, suggesting the calling of a convention for the purpose of adopting a uniform system for the analysis of commercial fertilizers, has met with favorable responses from a large majority of the gentlemen to whom it was sent. A like majority has imposed upon me the duty of fixing the time and place of said convention and issuing the necessary notices for the same. After correspondence with others, and due consideration of the interests involved, I have decided upon Wednesday, the 28th of July, as the time and Washington, D. C., as the place for the assembling of the proposed convention. You are accordingly respectfully and earnestly invited to be present and participate in the convention.

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[1] Proceedings of the convention of agricultural chemists called for the purpose of adopting a uniform method for the analysis of commercial fertilizers. Published by James P. Harrison & Co., Atlanta, Ga., 1880.

Every reasonable facility for the deliberations of the convention will be afforded by Hon. William G. LeDuc, Commissioner of Agriculture, who is in hearty sympathy with the object sought to be accomplished. I have appended hereto a list of the names of gentlemen to whom this circular will be sent.

Trusting you will find it convenient to attend and give the convention the benefit of your experience, and requesting that you will at once inform me by letter whether you will attend, I am, respectfully,

J. T. HENDERSON,
Commissioner of Agriculture.

PROCEEDINGS.

FIRST MEETING.

LIBRARY HALL, *July 28, 1880.*

In response to these circulars there assembled in one of the spacious halls of the Department of Agriculture, which was kindly set apart by the Commissioner of Agriculture, the following gentlemen:

Prof. R. M. Ballentine, United States Department of Agriculture.
Dr. C. Elton Buck, manufacturing chemist, Wilmington, Del.
Hon. A. P. Butler, commissioner of agriculture, State of South Carolina.
Dr. Peter Collier, Chemist of the United States Department of Agriculture.
Dr. M. G. Ellzey, professor Virginia Agricultural and Mechanical College.
Dr. C. A. Goessmann, Agricultural College, Amherst, Mass.
Prof. W. M. Habirshaw, analytical chemist, New York City.
Hon. J. T. Henderson, commissioner of agriculture, State of Georgia.
Dr. E. H. Jenkins, Connecticut Agricultural Experiment Station.
Dr. A. R. Ledoux, North Carolina Agricultural Experiment Station.
Dr. G. A. Liebig, analytical and manufacturing chemist, Baltimore, Md.
Prof. Arthur T. Neale, New Jersey State Experiment Station.
Dr. N. A. Pratt, State chemist, Georgia.
Prof. R. W. L. Rasin, manufacturing chemist, Baltimore, Md.
Dr. Charles U. Shepard, jr., chemist, State of South Carolina.
Dr. W. Simon, analytical chemist, Baltimore, Md.
Dr. C. C. Wellington, United States Department of Agriculture.
Dr. H. C. White, professor, University of Georgia.
Dr. P. B. Wilson, analytical chemist, Baltimore, Md.
Dr. Theo. R. Wolf, professor and State chemist, Delaware.

The convention was called to order at 3.30 p. m. by Dr. C. U. Shepard, jr., who nominated Hon. J. T. Henderson for president of the convention, reminding the gentlemen that it was owing to Judge Henderson's earnest efforts that they were brought together. Judge Henderson, being called to the chair, after thanking the convention for the honor done him, stated the object of the meeting as substantially set forth in the circulars above given.

Dr. A. R. Ledoux was then elected secretary of the meeting.

Dr. M. G. Ellzey addressed the convention, saying that he heartily indorsed the effort which Judge Henderson was making to secure uniformity in the analysis of commercial fertilizers. He recognized the need of some general understanding in the matter, and hoped that the discussions would take no limited range, but deal with more than one of the questions which have been the cause of difficulty between producers and farmers throughout the country.

Letters were read from Prof. S. W. Johnson, of New Haven, and others, heartily indorsing the object of the meeting and thanking Judge Henderson for his action in calling the same.

On motion of Dr. Ellzey the chair appointed a committee on a programme or order of business, to recommend to the convention what topics should be discussed. The following committee was appointed: Drs. Goessmann, Buck, and White. The committee recommended the following programme. The report was received and adopted.

PROGRAMME.

1. Preparation of the roll of the convention, and decision of the rights of parties present to participate in the discussion of various topics, and to vote upon the final judgment of the same.
2. Discussion of the method of estimating soluble phosphoric acid.
3. Discussion of method of estimating "reverted" phosphoric acid
4. Estimation of insoluble phosphoric acid.
5. Estimation of nitrogen.
6. Estimation of potash.

The committee consider the above the main topics which should receive the consideration of the convention. Other points proper for discussion, should time allow, are, perhaps, as follows:

7. Method of arriving at commercial valuations.
8. Agricultural and commercial valuation of "reverted" phosphoric acid.

In accordance with section 1 of the order of business, the secretary was ordered to make out and read the roll of the convention, together with the occupations and professions of the gentlemen present.

Dr. White moved that only those who are practicing, analytical chemists be considered entitled to vote on the final judgment of the meeting.

Dr. Ellzey opposed the motion, saying he would very much regret to see the convention limited in that way.

The secretary called attention to the fact that all the gentlemen present but three were practicing, analytical chemists, and entitled to vote under the above resolution.

After some further discussion, the resolution was adopted.

The convention then, on motion, took up the discussion of the second section of the programme—determination of soluble phosphoric acid.

Drs. Goessmann and Ellzey gave their opinions as to the extent and direction which the discussion should have.

It was moved by Dr. Ledoux that a committee of three be appointed by the chair to propose to the convention a method for the determination of soluble phosphoric acid.

Dr. Collier moved to amend by substituting "five" for "three."

Dr. Shepard moved, as a substitute, that the entire question of the determination of phosphoric acid in all its forms be referred to a committee of five.

After discussion, the following resolution was adopted:

Resolved, That a committee of five be appointed by the chair to consider sections 2, 3, and 4 of the order of business and report thereon.

The following gentlemen were appointed by the chair: Drs. Shepard, Goessmann, Liebig, Jenkins, and Wolf.

On motion of Dr. White, it was ordered that a committee of five be appointed to take into consideration sections 5 and 6 of the order of business and report thereon. Drs. Habirshaw, Wilson, Neale, Buck, and Pratt were appointed.

On motion, section 5 of the order of business was amended so as to include nitrates.

The convention then took a recess until 6.30 p. m., to allow the committee time to report.

The convention came to order at 7 p. m. The committee on sections 2, 3, and 4 (phosphoric acid) offered the following report, which, after reading and being discussed by several gentlemen at considerable length, was received and adopted.

REPORT.

It is recommended by your committee to whom was referred the selection of a method for the determination of phosphoric acid in commercial manures—

That this convention shall agree to adopt, provisionally, the methods recommended by Fresenius, Neubauer, and Luck in their article "On the best methods for the analysis of artificial manures."

Zeitschrift für analytische Chemie, X, p. 133, with the following suggestions:

1. That the flask containing the residue (after the extraction of the soluble phosphoric acid) and the solution of citrate be introduced into a cold water bath, whose temperature shall be rapidly raised to 40° C., and there maintained for one-half hour, the flask being shaken every five minutes.
2. That the determination of the "reduced" phosphoric acid be indirect.
3. That all the determinations be gravimetric.
4. That a committee of two, to be named by the chairman, be appointed to prepare, on the above basis, a detailed method for the analysis of commercial manures, and to distribute the same among the members of this convention and others interested by this action.

CHARLES U. SHEPARD, Jr.,
Chairman of Committee.

The following report of the committee on sections 5 and 6 of the programme (nitrogen and potash) was received and adopted:

REPORT.

Estimation of nitrogen and potash in commercial manures.

I. Determination of nitrogen (total):

(*a*) When the three forms of nitrogen are present (nitrates, ammonia salts, and organic nitrogen), a combustion with oxide of copper or plumbic chromate.

(*b*) When nitrates are not present, a combustion with soda-lime and the resulting ammonia estimated with platinum chloride or titrated with a normal solution (alkali).

II. Determination of nitric acid when in presence of ammonia salts and organic nitrogen:

(*a*) Nitrates and ammonia salts are brought into water solution and the nitric acid is converted into ammonia by Harcourt and Siewert's process.—(Zeitschrift für analytische Chemie, 1871, 334; Jour. Chem. Soc., 1862, 381; An. Chem. und Phar., 125, 293; Sutton Volumetric Analysis, London, 3d ed., 1876, 102 et seq.)

(*b*) Nitrates are brought into water solution and the nitric acid estimated by Schlossing's method, modified by Schultz, viz, distillation in presence of ferrous chloride with excess of hydrochloric acid. The NO gas is collected and measured.—(Schlossing's Original Paper, Annal de Chim., 3 ser., tom. 40, 479; Jour. für Pract. Chemi., 62–142.)

III. Determination of nitrogen existing as ammonia salts:

The solution in water is distilled with magnesium oxide and the ammonia estimated either by the platinum method or by titration with normal acid.

IV. Determination of the nitrogen when existing in a substance, in separate forms, as nitrates, ammonia salts, and organic nitrogen:

(*a*) Estimation of total nitrogen by I *a*.
(*b*) Estimation of total nitric acid by II *b* or II *a*.
(*c*) Estimation of total ammonia salts, III.
(*d*) Estimation of total organic nitrogen by difference.

V. Estimation of potash:

Only salts of potash soluble in water are considered in this report (except when the potash occurs in seeds, in which case previous calcination is recommended).

(*a*) Solution in water, removal of sulphates, phosphates, and magnesia by barium hydrate, clearing with oxalate or carb. ammonia and precipitating with platinum chloride.

W. M. HABIRSHAW, *Chairman.*

On motion, it was ordered that the two reports be referred to a committee of two, who should copy them, giving details of the methods to be employed, and send to each member of the convention a copy of the same.

On motion, a letter of Dr. S. A. Goodale was considered and referred to the above committee.

After remarks and discussion of the above reports, it was suggested that, since so many agricultural chemists were present, it would be desirable to effect a permanent organization, to meet from time to time and discuss topics of interest to the profession. Dr. Goessmann offered the following resolution:

Resolved, That this convention form a section in the subdivision of chemistry in the American Association for the Advancement of Science, and that their next meeting be held in Boston during the regular meeting of the aforesaid association.

On motion, Dr. Goessmann's resolution was adopted. Dr. Shepard thought it would be well to refer the matter to a committee to draw up a plan for a permanent organization, and offered a resolution to that effect. Drs. Goessmann and Wilson were appointed to arrange for a permanent organization of the convention, as called for in the resolution of Dr. Shepard.

On motion, section 7 of the order of business was taken up by the convention. A long discussion followed, which was participated in by Drs. Ellzey, Collier, Jenkins, and others. No final action was taken upon this section, but it will be further considered at the forthcoming meeting of the convention in Boston. The committee on permanent organization made the following report, which was received and adopted:

REPORT.

The committee on permanent organization propose that Dr. Goessmann be made chairman until the next annual meeting in connection with the American Association for the Advancement of Science, and that Dr. Ledoux be appointed secretary.

P. B. WILSON, *Chairman.*

On motion, the thanks of the convention were tendered Judge Henderson for his courtesy and skill as presiding officer.

On motion, the following resolution was unanimously adopted:

Resolved, That the thanks of this convention are hereby tendered to General LeDuc, Commissioner of Agriculture, for his courtesy; and also to Professor Collier, the Chemist of the Department, for his kindness and attention.

On motion, the convention adjourned.

The committee who were appointed to write out the details of the methods of determination of phosphoric acid have forwarded the secretary the following

REPORT.

Method for the determination of phosphoric acid in commercial manures.

1. Preparation of the sample. It is not to be ground, but may be broken up by hand, and should be thoroughly mixed as rapidly as possible and transferred to a tightly stopped bottle.

2. Determination of the soluble and "undecomposed" phosphoric acid.

(*a*) Two grams of the material, transferred to a suitable vessel, are rubbed up with a small quantity of cold water (carefully avoiding any pulverization), transferred to a filter and there washed with cold water, which is added at first in small successive portions until the washings no longer react acid.

Soluble phosphoric acid is determined in the filtrate.

(*b*) The filter, containing the "reverted" and "undecomposed" phosphates, is carefully spread on a glass plate. With the aid of a wash bottle containing 100 cubic centimeters of a perfectly neutral solution of ammonium citrate (sp. gr. 1.09) the residue is washed into a lipped porcelain mortar. The coarser portions are allowed to settle, and the fluid, with the suspended particles, is poured into a small flask. The residue remaining in the mortar is rubbed to a very fine paste and brought with the remainder of the ammonium citrate into the flask, which is then corked.

This flask is put into a cold water bath, the temperature is rapidly raised to 40° C., and there maintained for one-half hour, care being taken to shake the flask every five minutes. It is then removed and the contents immediately filtered.

The residue is washed two or three times with a mixture of equal parts of water and ammonium citrate solution, and used for the determination of "undecomposed" phosphoric acid.

3. The total phosphoric acid is determined in a separate portion of 1 to 2 grams.

The other details are as given by Fresenius, Neubauer, and Luck (loc. cit.).

The committee have read with great interest the communication of Dr. S. L. Goodale, referred to them, and beg leave to return it to the secretary for presentation at a future meeting of the convention, when its contents may receive the attention they deserve.

CHARLES U. SHEPARD, Jr.,
EWD. H. JENKINS,
Committee.

The above is respectfully submitted.

A. R. LEDOUX, *Secretary.*

J. T. HENDERSON, *Chairman.*

In harmony with the vote of the convention the association assembled again in Boston on the 27th of August, 1880. This meeting is also worthy of perpetuation in the printed proceedings of this association, and so the minutes are inserted in full:

Proceedings of the Second Meeting of the Convention of Agricultural Chemists, held at Boston, Mass., August 27, 1880.[1]

The meeting took place in the library of the Society of Natural History, which was kindly set apart for the use of the convention. The convention came to order at half past 2. Dr. C. A. Goessmann occupied the chair. About 25 gentlemen were present.

The minutes of the meeting in Washington were read and approved.

Drs. Caldwell, Kerr, White, Atwater, Sharples, and Ledoux took part in discussions as to the advantage of permanent organization, the choosing of a name, etc. A general opinion prevailed that for the present at least it would be sufficient to form a subsection or subdivision of a subsection of the American Association for the Advancement of Science. It was suggested by Dr. Clarke, of Cincinnati, that we unite with botanists, practical agriculturists, and others to form a subsection of agricultural scientists, instead of simply organizing as agricultural chemists. This proposition did not meet with general approval. It was pointed out that efforts were already being made to organize a club of scientific agriculturists; that in fact such an organization had been effected the preceding day. It was also stated that such an organization need not conflict in any way with one devoted especially to chemical work relating to and connected with agriculture.

The minutes of the Washington meeting having been approved, the chairman stated that the next business in order was the reading and adoption of the report of the committee of two, to whom was referred by the convention (for elaboration and amplification) the reports of the committees on the determination of phosphoric acid, ammonia, and potash, adopted by the convention in Washington. The reading of the report brought out considerable discussion as to the methods which were recommended, in which Drs. Atwater, Caldwell, and others took part. The reports were adopted provisionally for one year.

Dr. Clarke stated to the convention that a movement had been inaugurated to have a section of chemistry in the American Association for the Advancement of Science, and suggested that this very desirable object could possibly be attained more easily by showing the association that not only were the chemists ready to form such a section but were even ready to form at least one subsection—of agricultural chemistry—whenever the way was open. Dr. White offered the following resolution:

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[1] Published in the proceedings of the third meeting of the convention of agricultural chemists held at Cincinnati, Ohio, August 18, 1881. Jas. H. Folan, printer, 79 and 81 William street, New York. 1881.

Resolved, That a committee of three be appointed by the chair to take such steps as may be necessary for securing the formation of a permanent chemical section in the American Association for the Advancement of Science, and the establishment of a subsection of agricultural chemistry in such permanent section, should it be formed.

The chairman appointed as committee Drs. White, Caldwell, and Ledoux.

An extended discussion was then had concerning the best means for securing the cooperation and adoption of the best methods of analysis by not only the chemists in the convention, but all those whose duty it was to make analysis of commercial fertilizers throughout the country. Dr. Sharples thought methods indorsed by the convention would be considered binding by other chemists throughout the country, but considered that experiments should be made fully to establish the fitness of the methods proposed at the Washington meeting.

Dr. Ledoux said that while he thought we would still be more or less dependent for some years upon the thought and experiments of the chemists of the Old World, the time had come when we should make more experiments for ourselves, even if we do nothing more than confirm the methods and results of Fresenius, Neubauer, Luck, and others. He suggested that many chemists would be glad to institute any experiments needed to attain the end desired, and that the time had come to collate and examine the various methods of determining phosphoric acid, ammonia, and potash, which have from time to time been published by our agricultural chemists. He considered that the collection and examination of the methods published and their adoption and reduction to one system, after careful experimental research, would give to the final action of this convention an authority which would be recognized by every one. Several gentlemen expressed their willingness to make any experiments which might be desired, and to do their share in perfecting a scheme of analysis. The following resolution was unanimously adopted:

Resolved, That a committee of five be appointed by the chair to secure the cooperation and experimental research of agricultural chemists, to collect and examine the various published methods of fertilizer analysis, and to make a report at the next meeting of this convention; and that we individually pledge ourselves to conduct, for this committee, any experiments or tests which they may desire.

The chair appointed Drs. S. W. Johnson, C. U. Shepard, jr., Peter Collier, W. O. Atwater, and G. C. Caldwell.

It was moved by Dr. Collier that when we adjourn we adjourn to meet at the same time and place, in 1881, as the American Association for the Advancement of Science. Adopted.

It was moved and seconded that the present chairman and secretary hold over until the next meeting. Adopted.

On motion, the convention adjourned.

A. R. Ledoux, *Secretary.*

The third meeting of the agricultural chemists was held in Cincinnati August 18, 1881. In connection with the meetings of the Association of Official Agricultural Chemists, it is important, for record and also for reference, that the proceedings of this meeting be accessible to the members of the association. They are therefore inserted in full.

MINUTES.[1]

The meeting took place in the room in Music Hall assigned to the chemical section of the American Association for the Advancement of Science. Dr. Goessmann, the chairman appointed at the Boston meeting, being absent, the convention was called to order by the secretary, A. R. Ledoux.

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[1] Proceedings of the Third Meeting of the Convention of Agricultural Chemists held at Cincinnati, Ohio, August 18, 1881. Published by Jas. H. Folan, New York.

A large number of chemists was present; among them: W. O. Atwater, Middletown, Conn.; A. L. Baker, Baltimore, Md.; B. N. Baker, Baltimore, Md.; H. Carrington Bolton, Hartford, Conn.; G. C. Caldwell, Cornell University, New York; H. Y. Castner, New York City; A. F. Crowell, Woods Hole, Mass.; C. W. Dabney, jr., State chemist, North Carolina; E. W. Davison, Baltimore, Md.; G. W. Davison, Baltimore, Md.; E. P. Dunnington, University of Virginia; Albert C. Hale, Colorado; T. M. Hopke, New York City; R. C. Kedzie, University of Michigan; A. R. Ledoux, New York City; G. W. Lehmann, Baltimore, Md.; Nat. W. Lord, State chemist, Ohio; C. F. S. Lowe, Augusta, Ga.; W. Mager, Baltimore, Md.; J. G. Mattison, New York City; Lockwood Myricke, Boston, Mass.; Paul Schweitzer, University of Missouri; W. Simon, Baltimore, Md.; Eugene A. Smith, University of Alabama; J. Lawrence Smith, Louisville, Ky.; Alfred Springer, Cincinnati, Ohio; C. M. Stillwell, New York City; W. P. Tonry, Baltimore, Md.; G. Henry Williams, Baltimore, Md.; P. B. Wilson, Baltimore, Md.; C. Gilbert Wheeler, Chicago, Ill.; H. C. White, State chemist, Georgia.

Letters were read from Drs. Collier, Goessmann, Johnson, Liebig, Neil, and others, regretting their inability to attend the meeting.

In opening the meeting, Dr. Ledoux recited the history of the convention so far, and read extracts from the reports of the Washington and Boston meetings, showing what had been done. He called attention to the fact that there had been comparatively little complaint since the Washington meeting in regard to the results obtained in the determination of nitrogen, potash, total and soluble phosphoric acid; but that, in spite of honest endeavor on the part of chemists who attended the foregoing meetings to adhere strictly to the methods laid down and adopted by the convention, the determinations of insoluble or reverted phosphoric acid have shown the most unfortunate discrepancies. These discrepancies were clearly as great as they had ever been before there was any attempt to arrive at uniformity in method. He said it had been the experience of many that, working on the same sample, in the same laboratory, two chemists would get results absurdly at variance; and we have, as far as he could see, come no nearer a solution of the difficulties than we were two years ago. As a proof of this, Dr. Ledoux cited a notable example. Soon after the Washington meeting, Dr. Shepard very carefully prepared five samples of artificial fertilizers, and submitted them to a number of chemists specially engaged in agricultural analysis. Each analysis was made in duplicate or triplicate, following most carefully the methods laid down by the Washington convention, with results simply ludicrous, as far as insoluble phosphoric acid was concerned. These analyses were never published, but being privately circulated among some of the chemists who attended the Washington convention, tended to prove what many had found out in the meantime by their own experience, that not yet had a method been reached which, in different hands, would give even approximately uniform results. Dr. Ledoux further stated that another difficulty presented itself in the fact that we have, yielding more or less to our citrate solvent, not only truly "reverted" phosphoric acid, but insoluble phosphoric acid, too, in certain mechanical forms, such as in the Peruvian, Orchilla, Curaçoa, Bat, and other guanos.

Dr. Ledoux further stated what were the rules as to voting, etc., and the programme for business adopted by the convention at Washington, and said that these were adhered to in the adjourned meeting in Boston.

Dr. R. G. Caldwell was then called to the chair.

The minutes of the Boston meeting were read and approved.

The reports of committees being called for, Dr. White, chairman of the committee on permanent organization, reported that their efforts to establish a permanent section of chemistry in the American Association for the Advancement of Science were about to be successful, and that said section would probably be organized on the 19th. After the organization of said section the way would be opened for the organization of a subsection of agricultural chemists. The report was accepted.

Professor Johnson, chairman of the committee of five "to secure the cooperation and research of agricultural chemists on the present methods of fertilizer analyses," not being present and having forwarded no report, and Drs. Caldwell and Atwater being members of said committee, they were called upon by the chair for information. They reported that one or two communications had been forwarded to them by the chairman; but it was their opinion that no definite conclusions had been arrived at by the committee.

It was moved and seconded that the rule for voting adopted at the Washington convention, and adhered to in Boston, should also govern the present convention. This rule is as follows: "Only those who are practicing analytical chemists shall be entitled to vote on the final judgment of this meeting." Drs. Dabney, Schweitzer, and others then opened the discussion in regard to the present methods in use for the determination of insoluble or reverted phosphoric acid, calling attention to the dissatisfaction which existed with the present methods, and also showing the difficulties in the way of arriving at any method which would be universally accepted.

Dr. J. Lawrence Smith said that although he had not recently made any especial investigations with fertilizers he had for years made a study of soils, and he stated that the value of a phosphatic material depended as much on the soil as it did on the chemical condition of the phosphate. He considered that there was no such thing as an absolutely insoluble phosphate from an agricultural point of view, and that after the mechanical condition of the phosphate had been taken into consideration he did not know why some simple method of testing the relative solubility could not be arrived at by agreement. For example, why could we not use a given solution of dilute hydrochloric acid on a given weight of phosphate, allowing it to act for a given time at a given temperature, or some other equally simple plan.

Mr. R. W. L. Rasin, president of the Chemical and Fertilizer Exchange of Baltimore, then presented the following petition:

CHEMICAL AND FERTILIZER EXCHANGE,
RIALTO BUILDING, SECOND STREET,
Baltimore, August 18, 1881.

To the Association of Agricultural Chemists.

GENTLEMEN: The Chemical and Fertilizer Exchange of Baltimore City, of which I have the honor to be president, and the views of which on the question of analysis I respectfully beg to lay before you, is an organization formed for the advancement of the commercial character of this line of trade, and hence actively engaged in watching the closely allied interests of the guano industry, of agriculture, and of agricultural chemistry.

In submitting the following report, I beg leave to state that the exchange, in giving expression to the opinion hereinafter contained, has been guided by the experience of all its members. The grave importance of the decision at which this convention will arrive will, I trust, be readily conceded, and the exchange, it gives me pleasure to announce, entertains the firm belief that you will give its views the consideration to which the practical experience of its members—the manufacturers—appears to be entitled.

The method for the determination of reverted or precipitated phosphoric acid in fertilizers adopted provisionally at the convention of this association at Washington in July, 1880, has now been in practical operation for over two years, and has therefore undergone a thorough trial, and the result has been by no means satisfactory. The experience of the chemists corroborates the experience of the manufacturer. The exchange openly avows that the continuance of the citrate method, under the rules adopted at Washington, would be the cause of great dissatisfaction. Yet, in urging upon you the adoption of the oxalate process, with specified rules, in lieu of the citrate method, the exchange urges this change only and solely for the reason that, in their opinion, only the oxalate method metes out equal justice to manufacturer and farmer. The subjoined analyses will forcibly illustrate how the citrate method, under the Washington rules, does crying injustice to the guano trade and to the farmer. For example, a sample of acid phosphate analyzed by that process, allowing thirty minutes as time of digestion, at a temperature of 40° C., using 50 cc to 1 gram, gave:

$$\left.\begin{array}{r}\text{2.75 per cent soluble}\\ \text{4.54 per cent reverted}\end{array}\right\}\text{7.29 avail. phos. acid,}$$

while the same sample, allowing sixty minutes for digestion at 90° C., applying 100 cc, to 1 gram, showed:

$$\left.\begin{array}{r}\text{2.62 soluble}\\ \text{10.71 reverted}\end{array}\right\}\text{13.33 per cent avail. phos. acid.}$$

This demonstrates clearly that the citrate method, under the rules adopted at Washington, in July, 1879, fails to show the total amount of available phosphoric acid contained in the sample in question. For, if it were not contained therein, then the second analysis could not make it appear, and hence the reality of the existence of 13.33 per cent as against 7.29 per cent, as shown by adherence to the Washington rules, is indisputable. Now the manufacturer, as well as the farmer, is entitled to know the true character of the goods offered for sale or bought; the former, because the analysis determines the commercial value of his goods; the latter, because it is his interest to know what he is actually applying to the soil for its amelioration.

But, in all States where analyses are required and made by the respective departments of agriculture under the Washington rules, the manufacturer is given credit for much less than his goods are intrinsically worth, and the article is deteriorated in the eyes of the purchaser. The former, on the other hand, is led to believe that he is buying an inferior article, when, in point of fact, the actual ingredients far exceed his expectations.

A similar experiment with ammoniated goods gave the following results:

$$\left.\begin{array}{r}\text{Sol. phos. acid 3.59}\\ \text{Reverted phos. acid 8.16}\end{array}\right\}\text{Total avail., 11.75 per cent,}$$

under sixty minutes' digestion, 90° C. and 100 cc to 1 gram, while a strict observance of the Washington rules gave only—

$$\left.\begin{array}{r}\text{Sol. phos. acid 3.59}\\ \text{Reverted phos. acid 5.15}\end{array}\right\}\text{Total avail., 9.73 per cent.}$$

The latter analysis would thus debar from sale this fertilizer in all States where a minimum standard of 10 per cent is required.

How unjust it is to give the manufactured goods the character of an inferior article when they do not deserve it, how unjust to keep from the farmer the correct information as to what he is buying, need not be dwelt upon here. Suffice it to say, that the adoption of a uniform process, which assigns to each article its true intrinsic value, is an imperative demand recognized by all chemists. Nor is this all. The citrate process, under the Washington rule, has been the cause of much fault-finding with chemists, when, in point of fact, the scrupulously conscientious adherence to the above rules was all chemists could be blamed for. Yet they have been not infrequently blamed for incorrectness when they sent analyses to manufacturers which showed considerable less percentage of the various ingredients than the manufacturer full well knew must be—as a matter of fact, was—contained in the goods analyzed from the formula, and proportion in which the ingredients were put in. Thus the method which has been provisionally adopted two years ago has failed in every respect to be more than a fruitful source of complaint and friction.

It appears, therefore, not only expedient, but absolutely necessary to have a uniform method adopted which will fix the commercial value of fertilizers according to their intrinsic value, and assign also proper value to all phosphatic sources. Science must render a service to agriculture by giving the farmer correct reliable information as to what he is buying, and another service to the fertilizer trade by giving their goods the credit they deserve. As is well known, of all constituents of a fertilizer, the most important factor is the available phosphoric acid (whether derived from phosphate of lime or phosphate of iron), and the larger percentage of this is mostly furnished in the reverted or precipitated phosphoric acid.

The oxalate process, which this exchange respectfully urges upon this convention for favorable consideration, has, so far as known to the members of the exchange, been giving general satisfaction, and has, moreover, been used by many chemists in preference to the citrate method on account of its greater accuracy. It appears less liable to error, has shown the products of the manufacturing establishments to be what the farmer's experience confirmed them to be by the practical results obtained, and seems, therefore, open to the least objection.

In confirmation of this opinion I beg to hand you a letter of Dr. G. A. Liebig, and analyses by Drs. Liebig, Shepard, Castner, Collier, and Ledoux, all of which are respectfully submitted for your earnest consideration.

R. W. I. Rasin, *President.*
A. De Ghequier, *Secretary.*

Accompanying the foregoing petition were the following papers:

LABORATORY OF G. A. LIEBIG, PH. D.,
Baltimore, August 16, 1881.

A. DE GHEQUIER, Esq.,
Secretary of Chemical and Fertilizer Exchange, Baltimore.

DEAR SIR: Your favor of the 27th ultimo duly received. You ask me to give expression to such reasons as I may have for preferring the "oxalate" to the citrate method in the determination of precipitated or reverted phosphoric acid in commercial manures.

Upon this subject I think I can hardly say more than I have said already in the correspondence which you have in your possession, covering replies to interrogations propounded by a committee of your exchange. Still, as you desire further expression, I will, at the risk of repetition briefly give a few reasons, which have always been of sufficient weight with me, as a chemist, to cause me to favor the oxalate rather than the citrate method in such determinations. In this connection it is only proper that I should remark that when the subject was under consideration in Washington I urged my views, which have always been as they are now; but being in the minority, I was content with the provisional adoption of the citrate method, feeling sure that time would indicate the correctness and justice of those views more effectually than my simple protest.

In the remarks I make, please bear in mind that when I refer to either method it is with the understanding that it will be carefully and conscientiously followed. You will feel the force of this provision when I tell you it is only within a week or two that a prominent chemist wrote me that he should like to know a method by which all chemists could surely find the same results; to which I answered to the effect that no method would ever insure the correctness of chemists.

In the correspondence before named, I had the pleasure of telling your committee that identical or nearly identical results can be reached by either method. The difficulties, however, of doing the work correctly are more numerous with the citrate than with the oxalate method, and it is laid down that of two given methods the simpler is to be preferred, which is common sense.

One serious difficulty, I have found, is in the fact that the commercial ammonium citrate has a decided acid reaction, rendering the utmost caution necessary, so much so that it became a habit with me to manufacture it for myself; and this precaution becomes more necessary when we are dealing with articles containing ferric and aluminic phosphates. The chemist, not knowing the nature of the article sent him for examination, should, of course, prefer a method which is incapable of discrimination, which, in my opinion, is the case with oxalate, while citrate can discriminate.

It is, of course, idle to pretend at this time that a phosphate containing iron or alumina, if made available, is not as valuable agriculturally and commercially as any other phosphate containing an equal amount of so-called available phosphoric acid. Indeed, it is Mulder who goes so far as to attach the greater value to phosphate of iron, and my personal experience warrants the assertion that it is equally as valuable as phosphate free from such combination.

I do not see that I can say anything more than I have already said to your exchange, except that I hope the approaching meeting of chemists at Cincinnati—to which I am prevented from going—may adopt the method open to the least objection, and, as uniformity in results is the thing so much desired, in my opinion the oxalate method should be adopted provisionally or permanently, as the experience and wisdom of those present may decide.

Hoping this, in conjunction with my former letters, may convey my full meaning,
I am, dear sir, you obedient servant,

G. A. LIEBIG.

UNITED STATES DEPARTMENT OF AGRICULTURE,
Washington, August 5, 1881.

W. E. LAWTON, Esq.

MY DEAR SIR: Your letter of the 2d came duly to hand. Please accept my thanks for your promptness. Now, as to the method of analysis: I can assure you that I am very conservative, and by no means inclined to believe without question that the method adopted is the best one to determine the value of the phosphates analyzed. Of course, I don't mean their agricultural value, for you and other dealers can alone fix their commercial value. But I am aware that experiments alone upon the crop can determine the relative value of these different forms of phosphoric acid, and as a chemist, even, I could not now say what was the difference between that P_2O_5 soluble in excess of hot citrate of ammonia, and that in cold; or that soluble in oxalate solution. In fact, I do not know that there is any difference in its value to the growing plant. I assure you that in any arguments you may have to advance, you will have in me a listener as free from any prejudice as one can be who has been interested in these matters for twenty years. I hope that the very best method known, or capable of being devised, may be adopted for the analyses of these phosphates, and I am wholly with you to that end, and I think no agricultural chemist will be willing to oppose such a result being brought about.

Sincerely, yours, **Peter Collier.**

Massachusetts Agricultural College,
Chemical Department,
Amherst, Mass., August 9, 1881.

W. C. Lawton, Esq.,
President of the Navassa Phosphate Company, New York.

Dear Sir: I regret that previous engagements do not permit me, during the short period of time left between the arrival of your sample of phosphate (August 8) and the beginning of the Cincinnati meeting, to carry out your request regarding their chemical analysis as directed. As the results of the desired examination can not be secured, to answer your purpose as specified in your letter, as far as time is concerned, I shall not begin the work until otherwise informed. I expect that the committee appointed by me, as chairman of the Association of Agricultural Chemists at their Boston meeting, August, 1880—Profs. S. W. Johnson, Caldwell, Shepard, Collier, and Atwater—to investigate further the various current modes of fertilizer analysis, and to report at the comming meeting at Cincinnati, will do much, directly and indirectly, to reconcile contending views. One of the main objects of our young organization consists in a systematic effort to harmonize the interests of the farming community and the manufacturers of fertilizers, and thereby promote agricultural and industrial progress throughout the country. Please accept my thanks for your confidence.

Very respectfully, yours, **C. A. Goessman.**

The accompanying analyses were also exhibited by Mr. Rasin with the following explanation:

With a view of showing the relative merits of the Washington citrate, the "high" citrate, and an oxalate method of determining reverted phosphoric acid, three samples were very carefully prepared from Navassa guano, as follows: One acid phosphate marked "I," one acid phosphate marked "II," and one ammoniated phosphate. These samples were sent for analysis to nine different chemists with the request that they analyze them by the following methods:

A. The Washington method in all its detail.

B. The Washington method, with the exception of using 100 cubic centimeters of citrate solution for one hour at a temperature of 90° C.

C. By using oxalate of ammonia (without any definite instructions as to amount, time, temperature, etc.).

Analyses July and August, 1881.

OXALATE.

	Liebig.	Shepard.	Castner.	Collier.	Ledoux.	Ledoux.[1]
Acid phosphate, sample No. 1.						
Soluble				0.75	1.75	1.79
Precipitated				9.48	10.06	10.22
Total available				10.23	11.81	12.01
Insoluble				4.90	4.00	4.07
Acid phosphate, sample No. 2.						
Soluble	2.35	1.58		1.08	1.59	1.59
Precipitated	9.13	9.77		9.29	8.08	7.98
Total available	11.48	11.35		10.37	9.67	9.57
Insoluble	4.03	3.48		5.10	5.95	6.02

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[1] These analyses were made by a different chemist in the laboratory of A. R. Ledoux & Co.

Analyses July and August, 1881—Continued.

OXALATE—Continued.

	Liebig.	Shepard.	Castner.	Collier.	Ledoux.	Ledoux.[1]
Ammoniated sample.						
Soluble	2.78	2.36	....	....	2.02	2.07
Precipitated	6.36	7.38	....	....	8.19	8.00
Total available	9.14	9.74	....	....	10.21	10.07
Insoluble	3.92	2.98	....	....	3.17	3.30
Potash	1.12	1.34	....	....	.98	1.05
Ammonia	2.76	2.89	....	....	2.74	2.72

CITRATE.

[50 cc. 40° C. 30 min.]

	Liebig.	Shepard.	Castner.	Collier.	Ledoux.	Ledoux.[1]
Acid phosphate, sample No. 1.						
Soluble	....	....	2.75	0.75	1.75	1.79
Precipitated	....	....	4.54	6.49	5.73	5.89
Total available	....	....	7.29	7.24	7.48	7.68
Insoluble	....	....	8.52	7.89	8.33	8.40
Acid phosphate, sample No. 2.						
Soluble	....	1.43	....	1.08	1.59	1.59
Precipitated	....	8.10	....	6.29	5.17	5.19
Total available	....	9.53	....	7.37	6.76	6.78
Insoluble	....	5.30	....	8.10	8.86	8.81
Ammoniated sample.						
Soluble	....	2.27	3.58	....	2.02	2.07
Precipitated	....	7.63	5.15	....	5.87	5.88
Total available	....	9.90	8.73	....	7.89	7.95
Insoluble	....	2.82	4.71		5.49	5.42
Potash	....	....	....	....	.98	1.05
Ammonia	....	....	2.98	....	2.74	2.72

CITRATE.

[100 cc. 90° C. 60 min.]

	Liebig.	Shepard.	Castner.	Collier.	Ledoux.	Ledoux.[1]
Acid phosphate, sample No. 1.						
Soluble	....	....	2.62	0.75	1.75	1.79
Precipitated	....	....	10.71	11.79	12.66	12.92
Total available	....	....	13.33	12.54	14.41	14.71
Insoluble	....	....	2.35	2.59	1.40	1.37
Acid phosphate, sample No. 2.						
Soluble	....	1.43	....	1.08	1.59	1.59
Precipitated	....	12.09	....	12.47	12.61	12.52
Total available	....	13.52	....	13.55	14.20	14.11
Insoluble	....	1.31	....	1.92	1.42	1.48

[1] These analyses were made by a different chemist in the laboratory of A. R. Ledoux & Co.

Analyses July and August, 1881—Continued.

CITRATE—Continued.

[100 cc. 90° C. 60 min.]

	Liebig.	Shepard.	Castner.	Collier.	Ledoux.	Ledoux.[1]
Ammoniated sample.						
Soluble			3.59		2.02	2.07
Precipitated			8.16		9.62	9.57
Total available			11.75		11.64	11.64
Insoluble			1.60		1.74	1.73
Potash					.98	1.05
Ammonia			2.98		2.74	2.72

[1] These analyses were made by a different chemist in the laboratory of A. R. Ledoux & Co.

The available phosphoric acid, as obtained by the various methods, is inserted below for the sake of showing more plainly the different results:

OXALATE.

	Liebig.	Shepard.	Castner.	Collier.	Ledoux, 1.	Ledoux, 2.
Acid phosphate, No. 1				10.23	11.81	12.01
Acid phosphate, No. 2	11.48	11.35		10.37	9.67	9.57
Ammoniated	9.14	9.74			10.21	10.07

CITRATE.

[50 cc. 40° C. 30 min.]

	Liebig.	Shepard.	Castner.	Collier.	Ledoux, 1.	Ledoux, 2.
Acid phosphate, No. 1			7.29	7.24	7.48	7.68
Acid phosphate, No. 2		9.58		7.37	6.76	6.78
Ammoniated		9.90	8.73		7.89	7.95

CITRATE.

[100 cc. 90° C. 60 min.]

	Liebig.	Shepard.	Castner.	Collier.	Ledoux, 1.	Ledoux, 2.
Acid phosphate, No. 1			13.33	12.54	14.41	14.71
Acid phosphate, No. 2		13.52		13.55	14.20	14.11
Ammoniated			11.75		11.64	11.64

NOTE.—The "moisture" in these samples was not reported. The variation in some of the results is undoubtedly due to a difference in the amounts of this constituent.

Mr. Rasin also handed in letters received from a number of chemists expressing their views concerning the oxalate method; in some instances disapproving, in others expressing their willingness to abide by the decision of the convention. Professor Tonry discussed at length the disadvantage of the citrate method, especially emphasizing the injustice which it did to those fertilizers containing large amounts of iron and alumina, and in which the reversion had been caused by these bases instead of lime. Recent experiments were cited which had been made in England, Scotland, and Germany to prove that in many instances, at least, reverted phosphate of iron was as valuable agriculturally and the equivalent of phosphate of lime.

Dr. Simon called attention to the difficulty of obtaining neutral citrate of ammonia, or of maintaining it after it had been secured, and to the marked effect which was exerted by different degrees of alkalinity produced by the addition of ammonia for the sake of neutralization. In contrast to this, he called attention to the stability of oxalate of ammonia.

He was followed by Dr. Ledoux, who pledged himself, as he thought all chemists present would do, to adopt whatever method the convention indorsed. He called attention to the fact that the Washington and Boston meetings had each indorsed the method of Fresenius, Neubauer, and Luck, provisionally for one year; that the year had already expired, and consequently there is now no authorized or official method, so far as American agricultural chemists are concerned. He further called attention to the difficulty of filtering rapidly when the citrate solution is employed, and the consequent discrepancies in point of time which must exist where one solution, filtering rapidly, remained in contact with the solvent for a much shorter period than in the case of another.

Mr. Stillwell said he had used the citrate method for years, and in his hands he finds this method quite satisfactory. He found no difficulty in filtering all solutions containing the citrate rapidly if proper care was used. He considered the oxalate and citrate methods, when carried on under the same conditions, entirely the equivalents of each other in guanos and ordinary superphosphates, excepting when iron and alumina were present. In the latter case he had observed great discrepancies. The citrate process seemed to favor superphosphates free from iron and alumina, which, in his opinion, was rather unjust, as, in his experience, superphosphates containing iron and alumina gave as good results on the field as any others. In his experience two chemists in the same laboratory could use the citrate method with proper care, and have their work agree within reasonable limits. The same was true of the oxalate. In view of the fact that he has tried both methods, and that there was so much dissatisfaction with the citrate, and since he considered them, properly conducted, the equivalent of each other, excepting in the case of iron and alumina phosphates, he had concluded to adopt hereafter the oxalate method.

Professor Lord said he considered that a great part of the discrepancies and variations was due, not so much to the solvent, but to the differences in carrying out the details. He hoped that whatever method was adopted, the details would be so clearly and plainly stated it would be impossible to have any more trouble on this account. He objected to the term "reverted" as not implying the whole truth about the phosphates dissolved by the citrate or oxalate solvent and suggested that chemists adopt the term "Phosphoric acid soluble in —— at —— deg. C." (whatever solvent and temperature might be adopted). He hoped that not only the methods of conducting the analysis would be very clearly and definitely agreed upon, but that even the apparatus to be used in each case should be specified.

Dr. Lehmann stated that his home was in Weisbaden; that he had studied with Fresenius, and was thoroughly familiar with the method of Fresenius, Neubauer, and Luck; that he knows it was adopted mainly with a view to its application for the analysis of bone products and others where little or no iron was present. He too considers the difference in method and time of grinding, stirring, shaking, and filtering, etc., grave causes of discrepancy. In his experience oxalate of ammonia solutions filtered uniformly well.

Dr. Tonry moved that instead of the so-called citrate of ammonia method, the convention do adopt provisionally for one year oxalate of ammonia as a solvent.

Dr. Ledoux stated that there were three interests involved in whatever decision was arrived at by the convention; the interests of manufacturers, the interests of farmers, and the professional interests of the chemists. Since it was apparently impossible, either in this country or in Europe, with our present lights, to arrive at thoroughly satisfactory methods, rendering it impossible to stand upon entirely scientific grounds in the discussion, chemists must consider the commercial points at issue between buyers and sellers, and observe a strictly neutral and just middle ground.

Dr. White said that he had analyzed over 350 samples of fertilizers last year, and found little or no trouble with the Washington method. He not only checks his work by duplicate analyses, but again and again, when the same samples have been returned to him without his knowledge, he has found his previous work corroborated. The new analysis agreed with the former. He acknowledged that his analyses did not always agree with those of other chemists. He stated that we were in possession of but few results making comparison of the oxalate with the citrate method, but he did know that "an especial British commission, after considering the very subject which we are now discussing for over two years, decided that the oxalate process was the very worst of all, in regard to the discrepancies." Since, as has been stated, we are not all agreed as to what shall be included by the term "reverted," he was earnestly opposed to any change, for the present, from the Washington method, but preferred that the whole subject be again referred to a committee, with instructions to make certain tests which could be suggested. He further stated that we could not base a scientific discussion on the analyses of the samples of Navassa guano just reported, because we know nothing as to how they had been prepared, and their number was too few to allow us to generalize from their results. He therefore moved, as a substitute to Professor Tonry's resolution, that the subject be again referred to a committee to investigate and report; and that, until said report shall be made, the Washington method be adhered to.

Dr. Dabney seconded this motion, and he declared that, following the Washington method as nearly as possible, except in a few minor details, his results agreed closely, and he was entirely satisfied with the present system. He, too, had found by experience, that in artificially prepared reverted phosphate of lime, the Washington method was entirely satisfactory, but did not consider it always so in phosphates containing iron.

Professor Atwater said he was pleased to see a spirit of concession and harmony in the convention, and earnestly desired that all interests involved should be carefully considered and harmonized. It being 1 o'clock, he moved that the convention adjourn until 2. Carried.

The convention came together at 2 o'clock and Professor Tonry insisted that his motion should be put. He reiterated his previous statement that, in many legal controversies which he has been engaged as expert, the court favored the oxalate method as used in Baltimore. He simply desired to press his resolution that oxalate of ammonia be adopted, leaving the question of method to be settled in some other manner. He stated that he found the oxalate method best in point of expedition and accuracy.

Dr. Dabney protested against any change, explained the system of obtaining samples in North Carolina and of making analyses.

By courtesy, Mr. Tonry withdrew his resolution temporarily to allow a motion that, in the discussion which should follow, each speaker should be limited to five minutes. Adopted.

Dr. J. Lawrence Smith considered it possible that a fair way out of the difficulty would be to discard the term "reverted" altogether and simply report the amount of phosphate soluble in a given solution, whether of acid or not, as might be agreed upon.

Dr. Dabney again spoke, repeating his convictions that the citrate method would give equally correct, if not better, results than the oxalate method.

Mr. Rasin, on behalf of the manufacturers, stated that all manufacturers had been intensely annoyed and their business interests seriously interfered with by the great difference in the analyses of their goods, and consequently in the great difference in the commercial valuations as applied by the various State departments. While he, as president of the Chemical Exchange, had presented a petition stating candidly that they favored the oxalate method, he wished to say that all they wanted was justice and uniformity, and was willing that the convention should adopt the oxalate method, or the citrate method, with certain changes; either would satisfy the manufacturers.

Drs. Simon, Lehmann, Ledoux, and others followed, discussing the oxalate method. The last stated that since the European chemists have failed to agree on a definite method, examining the question from a chemical standpoint; since they have been discussing the question longer than we in this country, he feared we, too, would find it impossible to agree on any result. He had found it exceedingly difficult to keep the temperature absolutely within the limits prescribed by Fresenius, Neubauer, and Luck, but agreed with Mr. Rasin that we must strive for truth and uniformity.

Dr. Atwater said that the manufacturers had put their case fairly and honestly, and had agreed to abide by the decision of the chemists. It was clear, he thought, that they demanded, and rightly, that our method, if not just, should be at least uniform. He believed that we should make any change which appeared to approach nearer to uniformity than we are at present, and he stated that it seemed to him that the oxalate method was a shade nearer uniformity than the citrate.

Professor Dunnington examined in detail the reports of analyses of Navassa guano which had been submitted to the convention, and pointed out the fact that, although no instruction had been given as to what method should be employed in the ammonium oxalate test, and definite instructions had been given for each of the citrate tests, the discrepancies with the oxalate were considerably less than with either of the citrate methods.

Messrs. Stillwell, Ledoux, and others stated their readiness to abide by the decision of the convention, whatever it might be, as did Drs. Dabney, White, and others.

The question being called for, the chairman decided it was on the substitute offered by Dr. White. Dr. White was requested to put his resolution in writing. It was as follows:

Resolved, That the method provisionally adopted by the Washington meeting be continued for one year, and that the matter of the relative merits of the citrate and oxalate methods be referred to a committee of five, appointed by the chair, to report at a subsequent meeting.

Dr. Ledoux called attention to the extreme improbability of our being able, by any amount of experiment, to arrive at a scientifically accurate method, and considered it necessary to simply agree upon the solvent and method to be employed for the coming year and all stand by the agreement.

The substitute of Dr. White, being put, was lost by the following vote:

Aye—Atwater, Dabney, Lord, White.

No—Baker, Castner, Crowell, Davison, Lehman, Lowe, Mager, Simon, Stillwell, Tonry, Wheeler, Williams, Wilson.

The following gentlemen were absent or refrained from voting:

B. N. Baker, Bolton, Caldwell, Davison, Dunnington, Hale, Hopke, Kedzie, Ledoux, Mattison, Myricke, Smith, Schweitzer, Springer.

A number of gentlemen explained their votes. The motion was lost.

The question then recurred to the original motion of Dr. Tonry—that oxalate of ammonia be substituted for citrate as a solvent.

Professor Caldwell spoke upon this motion. He had listened to the statements of the various chemists with interest. He considered that the protection had been mainly for the benefit of the farmers and that it was time the manufacturers were protected a little. He was, therefore, in favor of trying the oxalate method for a while. It was all a matter of experiment, and if, at the end of the coming year, the oxalate method is found to be unsatisfactory, it can be readily changed.

The resolution of Professor Tonry being put, it was adopted by the following vote:

Aye—Baker, Castner, Crowell, Davison, Dunnington, Ledoux, Lehman, Lowe, Mager, Stillwell, Simon, Tonry, Williams, Wilson.

No—Atwater, Dabney, Lord, Wheeler, White.

Absent or refrained from voting—B. N. Baker, Bolton, Caldwell, Davison, Hale, Hopke, Kedzie, Mattison, Myricke, Schweitzer, Smith, Springer.

Dr. Ledoux offered the following resolution, which was unanimously adopted:

Resolved, That a committee of seven be appointed to consider the best method, and its details, for the determination of insoluble or reverted phosphoric acid by the use of ammonium oxalate; that this committee be instructed to report as soon as possible; and that we pledge ourselves to adopt the method chosen by the committee; that the committee be appointed as follows: One by the chair, three by the president of the Chemical and Fertilizer Exchange, and three to be the State chemists in charge of fertilizer control present at the meeting, viz, Drs. Dabney, Lord, and White.

The chair appointed Prof. W. O. Atwater. The president of the Chemical Exchange appointed Messrs. Lehmann, Simon, and Stillwell.

It was moved that a committee be appointed to continue the investigation of the whole subject of the determination of insoluble phosphoric acid, comparing the various methods now in use and reporting to this convention when prepared to do so.

The chair appointed Messrs. Ledoux, Goessmann, Jenkins, Liebig, and Stillwell.

It was moved that the committee appointed last year to provide for the absorption of the present convention into the American Association for the Advancement of Science, as a subsection of chemistry, be continued with full power to act. Carried.

Mr. Charles M. Stillwell then read the following paper:

On the preparation of superphosphates for analysis.

The few words which I have to say to-day will be confined chiefly to the sampling and preparation of a superphosphate for analysis. The large majority of superphosphates which are received for analysis in our laboratory are freshly made, containing often 22 to 25 per cent of water, full of lumps, hard and soft pieces of bone, meat, gristle, etc., from half an inch in diameter upward. It is impossible by following the plan adopted last year, of breaking up the lumps with the fingers, to get a fair average sample fit for analysis from such a superphosphate.

A case in point will partly illustrate this statement. Last year we sampled a cargo of superphosphate and divided our large average sample into exactly duplicate samples, which we sealed. These were sent to three other chemists of well-known reputation. The results obtained were as follows, reckoning to a dry basis for the sake of a better comparison:

Our result was total phosphoric acid on dry basis, 13.80 per cent; the results of the other chemists were 14.32, 14.64, and 15.21 per cent on dry basis. We were then told by the manufacturer that the cargo should contain 13.75 per cent phosphoric acid on dry basis, as estimated from previous analyses of the ingredients. There can be no doubt that a part at least of this difference was due to imperfect preparation of the sample for analysis, because this superphosphate was one of that class to which I referred a moment ago, a peculiarly difficult one to prepare for analysis.

Until about a year ago, the method adopted by me was one to which I have referred in my paper "On the estimation of precipitated or reduced phosphoric acid in superphosphates" (Proc. of Amer. Chem. Soc., vol. 2, p. 64). This plan was adopted by Dr. Walz many years ago, and later by myself, because it gave such uniformly accurate results. In brief, it was the drying of a large amount of the superphosphate at 100° C., grinding in a mortar, and sifting the dried mass through a sieve of about 100 meshes to the inch. The moisture left in the finely ground sample was estimated, and the results obtained by analysis were calculated back to the original sample. The process of drying reduced the amount of available phosphoric acid by about 0.10 to 0.15 per cent in an ordinary superphosphate, but this lower result might well be neglected on account of the greater accuracy obtained from the use of such a finely ground average sample.

About a year ago, when the use of Orchilla guano, mixed with an acid phosphate or an ammoniated phosphate, was begun by New York manufacturers, we found that this plan would not answer. During the process of drying, the undecomposed carbonate of lime in the Orchilla guano reacted on the soluble and reverted phosphoric acid and reduced a part of it to the insoluble form. For instance, a superphosphate dried at 100° C. gave of insoluble phosphoric acid 4.94 per cent; another portion of the same sample, air dried, gave of insoluble phosphoric acid 4.28 per cent. Another sample, dried at 100° C., analyzed as follows:

	Per cent.
Soluble phosphoric acid	2.68
Reverted phosphoric acid	6.18
Insoluble phosphoric acid	4.94

A portion of this sample, air dried, gave of—

	Per cent.
Soluble phosphoric acid	2.92
Reverted phosphoric acid	6.60
Insoluble phosphoric acid	4.28

Thus showing a loss of 0.66 per cent in the amount of available phosphoric acid caused by drying at 100° C. In an article by S. Drewsen, in Fres. Zeit. f. Anal. Chem., 1881, p. 55, the statement is made that it is immaterial whether a superphosphate is dried at 100° C. or not. But we know that a serious loss is occasioned by such treatment in samples containing Orchilla guanos.

This action of the carbonate of lime upon the available phosphoric acid goes on for weeks after the two are mixed together. An analysis of the sample referred to above as containing 4.28 per cent of insoluble phosphoric acid showed, a month after the first analysis, an insoluble of 5.29 per cent. This sample had been kept in a 2-quart fruit jar in a cool place; but an analysis of the cargo by another chemist, after it arrived at its port and had been kept in bulk for about the same time, showed an insoluble of 6.36 per cent. These insolubles, referred to in the analyses quoted above, were made by the citrate of ammonia method, as adopted two years ago.

The method which we have used for a year past for the preparation of superphosphates is as follows: The whole of the sample obtained, which may be 5 or 8 pounds, is sifted through a coarse iron sieve, with meshes one-quarter of an inch square. The lumps are rubbed through or broken in a mortar, and the whole operation is so rapidly done that no loss of moisture takes place. The well-mixed sample is then averaged, and a part bottled for the determination of the original moisture present, using 20 grams or more, as required.

An average of the remainder is taken and air dried, with no exposure to heat, until it is dry enough to be sifted, after grinding in a mortar, through a sieve of 20 meshes to the linear inch. One-half a gram of such a sample as this is a much better average than 2 grams of a superphosphate prepared without this preliminary drying. It is imperative that the moisture be determined in the prepared sample, no matter how short may have been the time employed for the fine grinding. The results obtained by analysis are then calculated to the original sample, as determined by the moisture present therein.

It being brought to the attention of the convention that the room they occupied was desired by the American Association for the Advancement of Science, the papers of Professor Collier, on "Sorghum and sugar," and of Prof. E. W. Hilgard, on the "Methods of soil analysis," were referred to the chemical subsection of the American Association for the Advancement of Science, where they would be read before a larger audience and receive more attention than could be bestowed upon them in the limited time at the disposal of the present convention.

It was moved that the committee appointed to fix upon the method for determining insoluble or reverted phosphoric acid by means of oxalate of ammonia be instructed to report to the secretary of this convention, and that he shall forward copies of their report to agricultural and other chemists throughout the country.

On motion the convention adjourned, to meet upon call of the chair, provided a meeting was necessary before their organization as a subsection of the American Association for the Advancement of Science.

(After adjournment nearly all the chemists present who were not already members of the American Association for the Advancement of Science joined said association.)

A. R. Ledoux, *Secretary.*

REPORT.

The following is the report of the committee of seven appointed for the purpose of preparing the datails of the oxalate method. The accompanying letter is also published, as it explains somewhat the action of the committee:

GRAND RAPIDS, MICH., *August 25, 1881.*

Dr. A. R. LEDOUX,
Secretary Convention Agricultural Chemists,
17 Cedar Street, New York.

DEAR SIR: Herewith I send you the minutes of the committee appointed to propose a method for determination of "reverted" phosphoric acid by ammonium oxalate.

As Dr. Stillwell, the secretary of the committee, was obliged to hurry away from Cincinnati, and was not to return directly to New York, and further, as it seemed to him as well as myself desirable to submit the draft of the report to the other members of the committee for approval, I undertook to attend to the latter task and forward the report to you. As I left Cincinnati somewhat hurriedly also, I have not found convenient opportunity to forward it until now.

As you will see, the committee felt that under the circumstances they could do no more now than propose a provisional and temporary plan, but have taken steps toward the proposing of something more nearly adequate to the demands of the case. It was, however, the feeling of nearly all, I think, that the requisite data will be gotten only after considerable research, and that without them it will be impracticable to propose a method that will command or even be entitled to the following of chemists generally.

Will you please see that Mr. Stillwell has opportunity to correct the proof of the report.

Yours truly,

W. O. ATWATER,
Chairman.

REPORT.

CINCINNATI, *August 19, 1881.*

Report of proceedings of the committee appointed by the Convention of Agricultural Chemists, August 18, 1881, to prepare directions for the use of ammonium oxalate as a solvent in the estimation of reverted phosphoric acid.

Present, Prof. W. O. Atwater, chairman, Drs. White, Lord, Dabney, Simon, Lehmann, and Stillwell.

This committee, which has been charged with the duty of proposing a method for the estimation of so-called reverted phosphoric acid by the use of ammonium oxalate as a solvent, finds itself at the outset seriously embarrassed; on the one hand by the lack of exact information as to what compounds of phosphoric acid are dissolved by ammonium oxalate and under what conditions; and on the other by the facts that so few of the chemists officially connected with the work of fertilizer analysis were present at the convention, and that all such who were present felt themselves, under the circumstances, unable to favor the proposed change.

In the first place it seems best to the committee to propose for temporary use a method which approaches as nearly as may be to those which have already been employed by some chemists; second, to attempt at least some investigations in the hope of obtaining more light upon the action of ammonium oxalate; third, so soon as they shall thus be placed in condition to warrant it, to suggest a plan for the coming year as they have been directed to do.

1. *Preparation of the sample.*

At least 250 to 300 grams are to be put through a sieve with meshes 3 mm. square (about one-eighth of an inch). All lumps are to be prepared by grinding in a mortar or by cutting until they will pass through the sieve. The whole is well mixed and an average sample bottled for analysis. Special care must be taken during this operation of sifting that no drying of the sample take place.

2. *Determination of the soluble and undecomposed phosphoric acid.*

(*a*) Two grams of the material, transferred to a suitable vessel, are rubbed up with a small quantity of cold water (carefully avoiding any pulverization), transferred to a filter and there washed with cold water, which is added at first in small successive portions until the washings no longer react acid.

Soluble phosphoric acid is determined in the filtrate.

(*b*) The residue upon the filter, containing the reverted and undecomposed phosphates, is carefully washed into a lipped porcelain mortar with the aid of a wash bottle holding 100 cc of a perfectly neutral solution of pure, crystallized ammonium oxalate. Each 100 cc of this solution contains 2 grams of the salt. The coarser portions are allowed to settle, and the fluid, with the suspended particles, is put into a suitable vessel. The residue remaining in the mortar is rubbed to a very fine paste and brought, with the remainder of the ammonium oxalate solution, into the same vessel.

A water bath containing 400 cc of water for each sample treated is brought to a boil, the flame is removed, and the vessel containing the oxalate solution is immediately placed in the boiling water. It is then left in the water bath for sixty minutes, being shaken every ten minutes. At the end of sixty minutes the vessel is removed from the water bath and the contents immediately filtered. The residue is thoroughly washed with cold water and used for the determination of insoluble phosphoric acid.

The chairman and secretary were directed by vote to prepare samples and a schedule for experimental work, and to invite the cooperation of chemists for trial analyses of the samples submitted.

The committee adjourned subject to call by the chairman.

CHAS. M. STILLWELL, *Secretary.*

SUPPLEMENT TO REPORT OF PROCEEDINGS OF THE CINCINNATI CONVENTION OF AGRICULTURAL CHEMISTS.

NEW YORK, *September 23, 1881.*

The following letter from Prof. S. W. Johnson has only just reached the secretary, after the foregoing report was printed and partially distributed. It failed to arrive in time for the Cincinnati meeting, although mailed before the middle of August, owing to misdirection. Owing to the great value attached to anything from Dr. Johnson in the line of agricultural chemistry, and the regret of our convention at the absence of his report, the secretary publishes the letter in this form rather than not at all.

A. R. LEDOUX, *Secretary.*

NEW HAVEN, CONN., *August 14, 1881.*

Dr. A. R. LEDOUX, *Secretary.*

DEAR SIR: I must beg you to present to the Association of Agricultural Chemists my deep regrets at being unable to make any satisfactory report on methods of analyses of superphosphates. I accepted the chairmanship of the committee, with appointment to which I was honored at the Boston meeting, after much hesitation and with many misgivings in view of the probability that I could command neither time nor strength to discharge the duty satisfactorily. Efforts to effect a meeting of the committee failed, because of the wide distances that separated them. Various investigations undertaken in the laboratory of the Connecticut Agricultural Experiment Station, although yielding instructive and valuable results, could not be brought to a satisfactory conclusion, being interrupted by the regular and necessary work of the station, and finally my vacation leisure finds me without the strength to digest the material that has accumulated, and to report the progress attained in a manner at all commensurate with the importance of the subject.

I will state a conclusion that is the result of much experience, viz, that the ammonium citrate method applied as directed by Fresenius, Neubauer, and Luck may easily give reasonably satisfactory results on the low-grade superphosphates usually found in our markets, but that it fails to extract the "reverted phosphate" when their quantity is considered.

Thus from "Curaçao guano," so called, containing 30 per cent of phosphoric acid, 50 cc of ammonia citrate, as exactly neutral as it could be made in one-half hour at 40° with constant and uniform agitation:

Extracted from—	Per cent P_2O_5.
Two grams Curaçao	5.6
One gram Curaçao	9.4
One-half gram Curaçao	13.7
One-quarter gram Curaçao	16.6
One-eighth gram Curaçao	21.0

It is evident, then, that for such phosphates the quantity of solvent must be increased.

In conclusion, I beg to be continued another year on the committee, or preferably to be discharged.

Yours, very truly,
S. W. Johnson,
Chairman of Committee.

After the adjournment of the Cincinnati meeting the interest in the collaboration of the agricultural chemists seemed to die out. There was a certain feeling of antipathy—perhaps it is not well to make it so strong as this, but a strong feeling of incongruity—existing between the trade chemists on the one hand and the official chemists on the other. It was an unvoiced sentiment pervading the organization to the effect that an association composed of trade chemists and official chemists contained elements of instability which would prevent it from ever becoming highly useful. Nevertheless, after the lapse of three years, Mr. Henderson again called a meeting, which was held at Atlanta, Ga.

In his address at the Atlanta meeting, May, 1884, Judge Henderson said:

> I soon became satisfied of two things: first, that the work of the State chemist was entitled to the highest confidence, because verified and sustained by some of the most skillful and experienced chemists in the land, some of whom are now before me; second, that the difficulty was due solely to radically different methods in the laboratory. I thereupon, after consultation with many of you now present, called a convention of representative analytical chemists, official and private, to consider the question. That convention, as you all know, met at Washington, D. C., on July 26, 1880. With its work you are all familiar. A provisional method, now universally known as the Washington method, was adopted by the convention, and generally by the chemists of the country in their laboratories. Adjourning to Boston, the members present formed themselves into a section of the American Association for the Advancement of Science.
>
> At the meeting of the association in Cincinnati on the 18th of August, 1881, the chemical section made some changes in the Washington method, radical in character, with the provision that the method so adopted should be of force during the year. Since that meeting many valuable experiments have doubtless been made by you, and much additional experience gained in the use of methods, and it is to be hoped that you are now prepared to adopt a satisfactory and permanent system. In calling this convention thus early in the season and in advance of the annual meeting of the Association for the Advancement of Science, I have been actuated by a sense of the importance of adopting a uniform and, if possible, a more generally satisfactory method of analysis in time to enable manufacturers, if necessary, to conform to the same in promulgating their work of and for the next season.

Judge Henderson followed up the movement thus begun, but which had remained in abeyance for three years, by issuing a call for the agricultural chemists to meet in the senate chamber of the capitol at Atlanta May 15, 1884.

The names of the gentlemen attending this convention are given in an earlier part of this publication.

The proceedings of the Atlanta convention are contained in a pamphlet edited by Dr. C. W. Dabney, the secretary of the Atlanta meeting, and published at Raleigh, N. C., in 1884. This pamphlet contains 60 pages. It begins with the opening address of Judge Henderson, from which a quotation has already been made.

Dr. C. U. Shepard, of Charleston, S. C., followed Judge Henderson in an introductory address. He said: "Again we are assembled to consider the inconsistencies of agricultural chemical analysis. That they pinch all of us there is no doubt." Dr. Shepard insisted that the chemists having official connection with agricultural colleges and experiment stations and boards of agriculture should take the initiative in establishing uniform methods of procedure. As a commercial chemist he expressed his entire willingness to collaborate with the official chemists in every possible manner, and also to receive and examine samples which might be submitted for comparative analysis. Dr. Shepard also read an important paper entitled "Concerning the nature of reduced phosphoric acid."

At the Atlanta meeting committees were appointed to consider methods of analysis. These committees were three in number, namely:

(1) On methods of determining phosphoric acid, consisting of S. W. Johnson, H. C. White, and W. C. Stubbs.

(2) On methods of determining nitrogen, consisting of P. E. Chazal, A. T. Neale, and J. A. Myers.

(3) On methods of determining potash, consisting of E. H. Jenkins, W. J. Gascoyne, and H. W. Wiley.

Papers were read by F. B. Dancy, on comparison of some methods of determining reverted phosphoric acid; by Professor Johnson, on comparison of the action of ammonium citrate solution on phosphates at different temperatures; by Dr. Shepard, on certain apparatus for the determination of reduced phosphoric acid; by Dr. Wiley, on the action of ammonium citrate on ground bone, and the Gooch crucible in phosphate estimations; by Dr. Shepard, on the insufficiency of the "Washington" method when applied to acid phosphates which have lain long in pile; by Dr. Memminger, on determining reverted phosphates by the use of ammonium oxalate; by Dr. Dabney, on the Ruffle and copper oxid methods of determining nitrogen; by C. B. F. Lowe, on the determination of nitrogen from nitrates by the soda-lime process; by Dr. Memminger, on methods of determining potash.

The reports of the three committees on methods of analysis were received, discussed, amended, and adopted. The bulletin of the proceedings of the Atlanta convention practically forms the first in the series of bulletins containing the methods of analysis of the Association of Official Agricultural Chemists. It was compiled on the plan which was followed for many years thereafter, of having the proceedings and methods contained in the same bulletin, which plan was only abandoned when the volume of matter to be considered was so great as to necessitate two separate publications.

The convention, when it adjourned, agreed to meet in connection with the American Association for the Advancement of Science, in Philadelphia, the following September.

The Philadelphia meeting was held September 8, 1884. Dr. E. H. Jenkins was appointed chairman and Dr. C. W. Dabney acted as secretary. A committee appointed at the Atlanta meeting to consider the advisability of organizing the association as a subsection of the American Association for the Advancement of Science recommended the formation of two associations.

First. The Association of Agricultural Chemists to be entirely distinct from the American Association, to which should be left the discussion of the methods of analysis, etc.

Second. The subsection of the American Association for the Advancement of Science to be open to all agricultural chemists for the purposes of investigation and discussion.

The unanimous opinion expressed in the discussion of this subject was that an organization entirely separate from the American Association would best advance the objects of the convention. A committee, consisting of Messrs. H. C. White, E. H. Jenkins, P. C. Chazal, J. A. Myers, and H. W. Wiley, was appointed to consider the form of organization and instructed to report the following day. The report of this committee, with a few later additions, forms the constitution of the association as it exists to-day.

On September 9 a formal organization took place, the present name of the association was adopted, officers for the following year were elected, and the convention resolved into the first annual meeting of the Association of Official Agricultural Chemists. Committees on phosphoric acid, potash, and nitrogen were appointed, and methods for the determination of phosphoric acid and potash in commercial fertilizers adopted as the official methods of the association.

The bulletin containing the proceedings of this meeting consists of eight pages of printed matter, in which are given the list of officers elected, the constitution, and the methods of analysis adopted officially by the association.

Through the courtesy of Hon. Norman J. Colman, Commissioner of Agriculture, the second annual meeting of the Association of Official Agricultural Chemists was held in the library of the United States Department of Agriculture, beginning September 1, 1885. The officers of the convention were as follows: President, Prof. S. W. Johnson; vice-president, Prof. H. C. White; secretary and treasurer, Dr. Charles W. Dabney, jr.; executive committee, Dr. E. H. Jenkins and Prof. H. W. Wiley.

In the absence of President Johnson, Vice-President White took the chair, and, Dr. Dabney also being absent, Mr. Chazal was requested to act as secretary. Commissioner Colman addressed the members, dwelling briefly on the objects of the association and declaring his hearty sympathy with them. He expressed the hope that the association would not limit its attention to uniform methods of fertilizer analysis, but would extend its work to general chemical analysis, and commended to its special attention the standard of purity of foods and methods of detecting adulteration.

The proceedings of this meeting were published as Bulletin No. 7 of the Division of Chemistry, Department of Agriculture, and embodied, aside from the address of Commissioner Colman, the reports of the various committees appointed at the previous meeting, and several papers on subjects pertaining to the work of the association.

The officers elected for the ensuing year were: President, H. W. Wiley; vice-president, Charles W. Dabney, jr.; secretary and treasurer, Clifford Richardson; executive committee, W. J. Gascoyne and H. A. Huston.

By invitation of Commissioner Colman the third annual meeting of the convention was held at the United States Department of Agriculture, August 26 and 27, 1886, and through his courtesy the proceedings were published as Bulletin No. 12 of the Division of Chemistry.

In Commissioner Colman's letter of invitation to the executive committee he again expressed the hope that the association would extend its investigations to other subjects than those immediately connected with the analysis of fertilizers.

At the opening of the convention the president, Dr. H. W. Wiley, addressed the association, reviewing the work already accomplished, presenting in detail methods of analysis of fertilizers in use in foreign countries and comparing them with the methods adopted by the association. Dr. Wiley closed his address by recommending that the investigations of the association be extended over a wider range of subjects, and expressed the opinion that every problem connected with chemical agricultural analysis was a proper subject for discussion at meetings. He suggested the advisability of appointing a committee to consider the propriety of revising the clause in the constitution which limited the membership and the scope of investigations.

Dr. Wiley's address was followed by the reports on phosphoric acid, potash, and nitrogen, together with various papers on each of the three subjects mentioned.

Up to this time no method for the determination of nitrogen had been adopted as official, and owing to the fact that no one method could be agreed upon it was decided that the association should recognize as official either the Ruffle, Kjeldahl, absolute, or soda-lime methods, when carried out according to the working details to be supplied by the committee. The three methods mentioned were therefore printed with the official methods of the association.

Officers for the following year were elected as follows:

President, E. H. Jenkins; vice-president, P. E. Chazal; secretary and treasurer, Clifford Richardson; executive committee, H. W. Wiley and M. A. Scovell.

At this meeting two additional committees were appointed, namely, on food stuffs and dairy products, and proper methods adopted for the work of each.

In Bulletin No. 16 of the Division of Chemistry are recorded the proceedings of the fourth annual convention of the association, which was held in Washington, August 16, 17, and 18, 1887. Thirty-five members were present, and the meeting was called to order by President Jenkins in the library of the Department of Agriculture.

The president briefly addressed the association, speaking of the importance of the work done, and urging particularly an amendment of the constitution so as to admit as members of the association chemists from agricultural colleges who exercised no official control over the analysis of fertilizers, soils, cattle foods, dairy products, and other materials connected with agricultural industry, and also the chemists from the Treasury Department. This amendment was adopted near the close of the session.

Then followed in their regular order the report of the committee on the analysis of cattle food, the report on dairy products, phosphoric acid, potash, and nitrogen.

In addition to the committees already existing, one was appointed to investigate the subject of the analysis of fermented liquors and another the methods of analysis of sugars.

The officers of the fifth annual meeting of the association were: President, P. E. Chazal; vice-president, W. J. Gascoyne; secretary, Clifford Richardson. John A. Myers and E. H. Jenkins were appointed additional members of the executive committee.

The convention was called in the library of the Department of Agriculture August 9, 1888, Mr. Chazal presiding.

The president omitted the usual address in order to proceed with the business of the convention.

The reports of the various committees were read and discussed; the methods for the work of the additional committees appointed at the previous meeting adopted and ordered to be printed with the official methods of the association. Prof. F. W. Clarke, of the Geological Survey, addressed the members of the association on the desirability of forming a national chemical society, and in harmony with this idea a committee, consisting of Messrs. H. W. Wiley, W. C. Stubbs, and E. A. de Schweinitz, was appointed to represent the association in any action which might be taken in this direction.

At this meeting an amendment to the constitution was adopted which put each of the subjects considered by the association in charge of one person, called a reporter, instead of a committee of three, as was the previous custom.

The proceedings of this meeting were published as Bulletin No. 19 of the Division of Chemistry.

The sixth annual meeting of the Association of Official Agricultural Chemists was held in the Seed Division of the Department of Agriculture, beginning September 10, 1889. The convention was called to order by the president, Prof. John A. Myers. The other officers of the convention were as follows: Vice-president, M. A. Scovell; secretary, Clifford Richardson; executive committee, H. W. Wiley and William Frear.

The session was opened with an address by Hon. Edwin Willets, Assistant Secretary of Agriculture. He called attention to the fact that since the last meeting of the association the Department of Agriculture had become an executive branch of the Government, and dwelt especially on the work of the agricultural experiment stations and the important place held by chemistry in the work.

Secretary Willets was followed by President Myers, who addressed the convention at some length. He spoke of the objects of the association and laid special stress on the necessity of such accuracy and reliability of methods as to compel respect for and trust in the conclusions of the association. He cited statistics showing the influence of the association on commercial activity, and compared its work with that of foreign organizations having the same object in view.

The feasibility of organizing a national chemical society was discussed at length at this meeting, and a motion was made and carried that the association should approve the proposition.

Reports of the various committees were presented and discussed and such action taken as the association deemed necessary.

Clifford Richardson at this time resigned the position of secretary and H. W. Wiley was chosen to fill the vacancy.

Bulletin No. 24 of the Division of Chemistry, containing 235 pages of printed matter, recorded the proceedings of this meeting.

The officers of the seventh annual convention of the association were: President, M. A. Scovell; vice-president, G. C. Caldwell; secretary, H. W. Wiley, with J. A. Myers and E. H. Jenkins as additional members of the executive committee.

The meetings were held in the lecture hall of the United States National Museum, beginning August 28, 1890.

The convention was called to order with President Scovell in the chair, who spoke to the members, congratulating them on the rapid advancement of the organization and the progress made in establishing reliable methods of analysis. A large part of President Scovell's remarks was devoted to recommendations in regard to special lines of the work of the association.

Following the president's address, the regular business of the association was taken up. On the morning of the second day the association was addressed by Hon. Edwin Willets, the Assistant Secretary of Agriculture, in a few well-chosen remarks. The work of the convention was then resumed.

At the date of this convention the work of cattle foods had become so extended that it was deemed necessary to divide the work between two reporters, one to consider foods high in carbohydrates (feeds, grains, and their milling products, etc.), and the other to devote himself to foods low in carbohydrates (coarse fodders, oil seed, residues, etc.). A reporter was also appointed to consider the subject of soil and ash analysis.

The committee appointed on the organization of the national chemical society reported that it had conferred with a similar committee appointed by Section C of the American Association for the Advancement of Science, and suggested that a committee of five be appointed by the Association of Official Agricultural Chemists to cooperate with like committees of Section C of the American Association, the Washington Chemical Society, and similar bodies, in calling a conference of chemists at some central point during the winter to consider the best means of organizing such a society. The report was agreed to, and Messrs. H. W. Wiley, W. C. Stubbs, G. C. Caldwell, William Frear, and H. H. Nicholson were selected to represent the association in the matter.

At this meeting a committee was also appointed on ways and means for securing a more thorough chemical analysis of foods and feeding stuffs, and also one on a chemical exhibit at the World's Columbian Exposition to be held in Chicago.

The proceedings of the seventh annual meeting are incorporated in Bulletin No. 28 of the Division of Chemistry.

On August 13, 1891, the eighth annual convention of the Association of Official Agricultural Chemists was called in the lecture hall of Columbian University. President Caldwell presided and addressed the members, giving a brief review of the history and existing conditions of efforts, both at home and abroad, to establish uniformity of methods of chemical analysis.

The vice-president of the eighth annual meeting was N. T. Lupton; secretary, H. W. Wiley, and E. B. Voorhees and R. C. Kedzie members of the executive committee.

The reports of the various reporters followed in regular order, and many interesting papers were presented relating to subjects under consideration by the association. The meeting was adjourned on the afternoon of August 15, and the proceedings published as Bulletin No. 31 of the Division of Chemistry, a pamphlet containing 253 pages of printed matter.

The ninth annual meeting of the association was called to order by the president, Mr. N. T. Lupton, Thursday, August 25, 1892, in the lecture hall of the United States National Musuem. The other officers of the convention were: Vice-president, S. M. Babcock; secretary, H. W. Wiley; executive committee, C. L. Penny and H. A. Huston.

According to the usual custom, the president opened the association with an address. President Lupton spoke especially on the various methods of analysis adopted by the association, and impressed upon the members the necessity of attaining such uniformity in their processes and accuracy in results as to command the confidence of chemists and interested persons all over the world. The reports on the several subjects were considered by the association. Then followed a discussion of results obtained, amendments to methods employed, and papers presented by other members of the convention. During the afternoon session of the second day, the Hon. Edwin Willits, Assistant Secretary of Agriculture, spoke to the members, congratulating them upon the good work accomplished by the association, and extended them a hearty welcome on behalf of the Department of Agriculture. At this meeting a resolution was adopted to appoint a committee to act in conjunction with committees appointed by the American Chemical Society, the American Association for the Advancement of Science, and the World's Columbian Auxiliary, for the purpose of securing an international congress of chemists during the summer of 1893 at Chicago.

The proceedings of the ninth meeting of the association were published in Bulletin No. 35 of the Division of Chemistry.

In Bulletin No. 38 are incorporated the proceedings of the tenth annual convention of the association. The officers of the meeting were: President, S. M. Babcock; vice-president, E. B. Voorhees; secretary, H. W. Wiley; executive committee, B. W. Kilgore and H. H. Harrington.

President Babcock addressed the association, speaking of the advantage of meeting in Chicago at that time and of coming in contact with representatives of foreign societies of agricultural chemists. He briefly reviewed the methods of analysis employed by the association, commending the progress made, and in some instances pointing out faults in the processes. The regular order of business was then taken up, reports read and discussed, various papers presented, officers for the ensuing year elected, etc.

At this meeting Dr. Wiley called attention to the fact that the association had met with a serious loss in the death of Dr. N. T. Lupton. Dr. Lupton in a sense was a charter member, attending all the meetings and contributing valuable work to the proceedings. Dr. Wiley moved that in honor of Dr. Lupton the members present should rise. Several other members made remarks expressing sorrow at the death of Dr. Lupton, and the motion to rise was unanimously carried. The association adjourned August 26.

On August 23, 1894, the eleventh annual meeting of the association convened in the lecture hall of the United States National Museum, the vice-president, Mr. H. A. Huston, occupying the chair in the absence of the president, Mr. E. B. Voorhees. The other officers of the meeting were: H. W. Wiley, secretary, with B. B. Ross and C. D. Woods as additional members of the executive committee. Mr. Huston read the president's address, in which an outline of the progress of the association from the time of its organization was given, special mention being made of the position the association had taken in regard to cooperating with the National Fertilizer Association in the abolishment of commercial valuation of fertilizers. It was stated that strong grounds had been taken by prominent members of the association against taking any part in national legislation, and a change in the constitution had been made which relieved the association from taking any definite position in the matter. The president in his address referred to the cooperation with foreign chemists authorized at the previous meeting, and stated that as a result of the action of the executive committee in the matter, over 250 leading foreign chemists had been invited to take part in the work of the association. At the conclusion of the address the regular order of business was taken up.

At the afternoon session of the convention Hon. Charles W. Dabney, Assistant Secretary of Agriculture, spoke briefly to the members. He referred to what might be called the first meeting of the association, at Atlanta, and gave pleasant assurances of his hearty support to the organization.

At this meeting a communication was read from the Society of Leather Chemists, asking to be incorporated in the association, and also requesting that a reporter on tannin be appointed. After some discussion the motion was put to the convention and carried, and a reporter on tannin was appointed for the following year.

An amendment to the constitution was also adopted authorizing the president to appoint associate reporters. Their duties were not to be defined, but it was understood that they should prepare themselves to take the place of the reporters.

At this meeting a committee, consisting of Messrs. L. L. Van Slyke, R. de Roode, and W. D. Bigelow, was appointed to edit and rewrite the methods of analysis. A committee of five was also appointed for the purpose of making such changes in the methods of analysis as the discussions during the meeting should prove necessary.

The convention was adjourned August 25, and the proceedings are incorporated in Bulletin 43 of the Division of Chemistry.

The twelfth annual meeting of the association was held in the lecture hall of the United States National Museum, beginning September 5, 1895. The meeting was called to order by the president, Mr. H. A. Huston. The other officers were as follows: Vice-president, B. B. Ross; secretary, H. W. Wiley; additional members of the executive committee, E. H. Jenkins and F. W. Woll. President Huston opened the convention with a few brief remarks, calling attention to some points in the constitution which he thought were not properly interpreted by the members of the association. He strongly advised that more attention be paid by the association to the question of food for man, stating that the only work done was represented in the reports on dairy products and sugar.

The convention, after a short recess employed to fix upon an order of business, was addressed by Hon. J. Sterling Morton, Secretary of Agriculture, in a few words extending a welcome to the organization and expressing his approval of its work and objects. The regular work of the meeting was then pursued.

The sentiment of the convention seemed to be that a committee, to consider in what way the association could be of service in formulating a pure-food law, could do good work, and accordingly such a committee was appointed, consisting of Messrs. H. W. Wiley, H. A. Huston, John A. Myers, and A. S. Mitchell.

The proceedings of the association had gradually assumed such large proportions that at this time it was deemed necessary to issue two separate volumes. Accordingly the proceedings of the twelfth annual convention were published as Bulletin 47 of the Division of Chemistry, while the methods of analysis were published as Bulletin 46. The meeting adjourned September 7.

In Bulletin 49, Division of Chemistry, are published the proceedings of the thirteenth annual meeting of the Association of Official Agricultural Chemists, which convened November 6, 1896, in the lecture hall of the National Museum. The officers of the meeting were: B. B. Ross, president; William Frear, vice-president; H. W. Wiley, secretary, and H. J. Wheeler and F. W. Traphagen additional members of the executive committee.

The president in his address touched briefly upon the progress made by the association in its various branches of work, and referred to the publication of its methods both in French and German as an indication of the recognition of their value by foreign chemists.

The reports on the various subjects followed this address, together with the presentation of papers, discussion of results, etc.

A committee was appointed at this meeting to prepare a suitable set of resolutions on the death of Hon. Edwin Willits, in whom the association had a very strong friend.

The meeting was adjourned November 9.

The fourteenth annual convention was called to order by the president, William Frear, in the lecture hall of the Columbian University October 26, 1897. The other officers of the meeting were: Vice-president, A. L. Winton; secretary, H. W. Wiley; additional members of the executive committee, B. W. Kilgore and Arthur Goss.

The meeting was opened with an address from the president. The tenor of his remarks was that while the prime work of the association was along lines important to the official agricultural chemist, it should also be pushed in a large measure along more distinctly scientific lines. In connection with the work on food adulteration, President Frear cited statistics showing the value of the food products of the country, amount of consumption, etc.

Following the president's address, the regular business of the association was taken up, reports read, papers presented, results and methods discussed, committees appointed, etc. It was decided that the reporters on the various subjects could be more properly called referees, and the name was accordingly changed.

On the morning of the second day the association was addressed by Hon. James Wilson, Secretary of Agriculture, who extended to the organization the courtesy of the Department.

The meeting adjourned October 28, and the proceedings are incorporated in Bulletin 51 of the Division of Chemistry.

The fifteenth annual convention of the association met in the lecture hall of the Columbian University, beginning November 11, 1898. The officers of the meeting were: President, A. L. Winton; vice-president, R. C. Kedzie; secretary, H. W. Wiley; additional members of the executive committee, M. A. Scovell and J. L. Hills.

The meeting was opened with the usual address of the president. Mr. Winton spoke of the purposes for which the association was organized, dwelling briefly on each of the various subjects considered by it. Then followed the regular order of business. A referee was appointed at this meeting to consider the subject of insecticides, and it was also voted that Bulletin No. 46 should be revised so as to include in it the changes made in the methods from time to time.

Mr. M. E. Jaffa, of Berkeley, Cal., was present at the meeting, and extended to the association a cordial invitation to hold its next meeting in San Francisco. He spoke of the advantages of a meeting on the Pacific coast, and assured the members of a hearty welcome from their scientific brethren in the West. The decision of the matter was left to the executive committee.

At this meeting delegates to the National Pure Food Convention were appointed. The last day of the convention Secretary Wilson addressed the members, speaking of the good work of the association and of the necessity for such work. The meeting adjourned November 14, and the proceedings are published in Bulletin 56 of the Division of Chemistry.

The CHAIRMAN. I suppose that no action in regard to this paper is necessary.

The referee on nitrogen not being present, the secretary asked leave to insert the report when received, which was granted.

REPORT ON NITROGEN.

By F. S. SHIVER, *Referee.*

At the suggestion of the secretary of the association, Dr. H. W. Wiley, I will give first a short review of some of the processes which have been suggested for the determination of the availability of organic nitrogen.

Klinkenberg and Stutzer[1] first proposed the pepsin-hydrochloric acid method for the determination of the availability of organic nitrogen.

Morgen[2] has proposed the method of putrefactive fermentation for determining nitrogen availability.

Wilson,[3] among others, has made use of a modified pepsin method, namely, the pepsin-pancreative method, for the determination of the availability of organic nitrogen.

This method was investigated last year by the referee on nitrogen under the name of the modified pepsin method. The results of this investigation, stated in the words of the referee, were as follows:

> The results obtained agree fairly well and compare favorably with the regular pepsin method, except in the case of leather. With this substance the method is worthless on account of the action of sodium carbonate on leather. In addition to this serious objection the method is not likely to be used very often on account of the trouble of manipulation, requiring as it does two digestion periods of twelve hours each and also two filterings, making it very inconvenient to attend to. The filtering is very slow, in some cases requiring two or three filters and one or two days' time.

The pepsin-pancreative method therefore possessed no advantages, but, on the other hand, some disadvantages, as compared with the pepsin-hydrochloric acid method.

The conclusions of the Connecticut Station[4] in regard to the Morgen putrefactive fermentation method for the determination of the availability of organic nitrogen were as follows:

> This test of putrefaction draws the same line between the two classes that was drawn by the pepsin digestion.
>
> Since the putrefactive fermentation method requires more time than the pepsin-hydrochloric acid method, and since it is more objectionable in the manipulations

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[1] Jour. für Landw., 1882, p. 363.

[2] Landw. Versuchs St., 1880, p. 50.

[3] Journal Society of Chemical Industry, vol. 10, p. 118.

[4] Twentieth Annual Report, p. 192.

necessary to carry it out than is the case with the pepsin-hydrochloric acid, our preferences would naturally turn to the pepsin-hydrochloric acid method as compared with the nitrogen putrefactive fermentation method. Under these circumstances, therefore, it is not strange that we were content up to a short time ago to accept the pepsin-hydrochloric acid method as the best one available for the determination of nitrogen solubility.

Several serious objections have been lately urged against the continued use of the pepsin-hydrochloric acid method. It has been shown conclusively that the pepsin-hydrochloric acid method fails to give the correct measure of the availability of the nitrogen in horn meal and hoof meal. This fact, coupled with the time-consuming digestion incident to the carrying out of the process, has stimulated many to investigate this subject for the purpose of finding out, if possible, a more rapid and at the same time more trustworthy method for the determination of nitrogen availability.

Hayes[1] has proposed several new methods for the determination of nitrogen availability, among them fractional treatment with sulphuric acid, digestion in barium hydroxid and in potassium permanganate (alkaline, acid, and neutral solutions).

The conclusions of the author regarding these methods were as follows:

> In conclusion, it may be said that of the various methods tried the digesting in potassium permanganate solutions gives most encouragement.
>
> Whether, if it is in some way modified, it can be made useful, has yet to be proven by comparisons with plant tests on the same material.

The permanganate methods, thus suggested, were taken in hand by the nitrogen referee in 1896, but were not thoroughly tested for lack of time. Among the recommendations of the referee for this year (1896) we find the following:

> That the nitrogen reporter for 1897 be requested to investigate further the potassium permanganate method for determining the availability of organic nitrogen * * *.

The referee on nitrogen for 1897, pursuant to the wishes of the association, subjected the potassium permanganate methods (alkaline, acid, and neutral solutions) to a thorough test. As a result of this work no definite conclusions could be drawn, but the methods were of sufficient promise to induce the referee to recommend "that the potassium permanganate method for determining the availability of organic nitrogen be further studied next year, with especial reference to material of known inferiority.'

The referee on nitrogen for 1898 has again taken up this matter, and has made a further study of the potassium permanganate method, in comparison with the pepsin-hydrochloric acid method and a modification of the pepsin method, as suggested by Mr. Patterson, of Maryland. The potassium permanganate method, suggested for use this year (1898), consisted of a half-hour digestion in a 2 per cent neutral solution, the acid and alkaline solutions having been shown to be unsatisfactory in not giving concordant results. The referee, commenting on the results obtained by this method, remarks:

> By an examination of Table IV it will be seen that there is a great lack of agreement in the results obtained by the different analysts, and on some materials it seems almost impossible to obtain concordant results in the same laboratory.

It was thought by some at this time that it would be desirable, instead of using the same amounts (1 gram) of material in all cases, to use equal amounts of nitrogen as a basis.

In the methods of Jones and Street, to be described later, 4½ and 7½ per cent of nitrogen, respectively, are used as a basis for the two methods. Among the recommendations of the referee for 1898 we find the following:

> The only recommendation which your referee wishes to make on this subject is that the potassium permanganate methods for the determination of the availability of organic nitrogen be further studied next year, especially some modification of the alkaline permanganate method.

As a result of all this work two well-defined methods, involving the use of potassium permanganate, have been worked out. I refer to the Street method, in which use is made of a neutral solution, and to the Jones method, in which use is made of an alkaline solution.

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[1] Bulletin 47, Division of Chemistry, U. S. Department of Agriculture.

Both of these processes are apparently quite promising, and a detailed discussion of them will follow the results reported later on in this report.

WORK OF AVAILABILITY OF ORGANIC NITROGEN FOR 1899.

Early in March the following circular letter was sent out to all those who were supposed to be interested in this line of work:

MARCH 15, 1899.

DEAR SIR: I desire to know if you will cooperate with me in the work on nitrogen for the association this year. The work will be limited to a further study of methods for the determination of the availability of organic nitrogen. In accordance with the wishes of the association the permanganate method will be further studied in this connection.

There will probably be eight or ten samples of representative organic nitrogenous materials. If possible these will be samples of material on which vegetation tests have been made.

Please let me know at your earliest opportunity your wishes in regard to the matter.

Very truly,

F. S. SHIVER, *Referee on Nitrogen.*
W. R. PERKINS, *Associate.*

From this circular nine favorable replies were received.

In April, accordingly, seven samples were sent out to each party expressing a desire to take part in the work.

Of the nine chemists who expressed a willingness to undertake the work seven have sent in reports more or less complete.

These samples, with the exception of No. 1, were secured from the New Jersey station through the kindness of Mr. J. P. Street.

Along with each set of samples there was sent a letter containing the directions to be used in the different methods.

In the preparation of the samples, I would say that they were ground to pass a sieve having circular perforations 1 millimeter in diameter, as directed by the methods of the association.

The samples were then mixed thoroughly, and all samples were taken out at once from the same pile.

While the referee was directed by the association only to investigate the alkaline-permanganate method, yet it was thought desirable to include also the Street method, which, from the results obtained at the New Jersey station, bids fair to be a useful process in this connection, and also the pepsin-hydrochloric acid method, which for years has been the standard.

The letter of directions which accompanied each set of samples was as follows:

DEAR SIR: I have sent you by express seven samples of organic nitrogenous material for the work on availability for the association.

No. 1 is cottonseed meal; No. 2 is ground fish; No. 3 is dried blood; No. 4 is tankage; No. 5 is ground bone; No. 6 is hoof meal; No. 7 is garbage fertilizer.

First determine total nitrogen in all samples.

Then determine availability of organic nitrogen by the following methods:

I. *Neutral permanganate method* (Street).—Into a 600 cc Erlenmeyer flask weigh an amount of the material equivalent, approximately, to 0.0750 gram of nitrogen. Digest this with 100 cc of permanganate of potash solution (16 grams $KMnO_4$ to 1,000 cc of water) in a steam bath or a water bath, where the water is kept at a constant boil for thirty minutes.

Filter on a folded filter without pressure, and wash thoroughly with cold water.

Then determine the nitrogen in the residue by the ordinary Kjeldahl method.

II. *Alkaline permanganate method* (Jones).—Weigh an amount of the material equivalent to 0.0450 gram of nitrogen into a 500 cc flask and add 100 cc of an alkaline permanganate solution (16 grams $KMnO_4$ and 150 grams of NaOH to a liter). The flask is connected with a distilling apparatus, and its contents digested for an hour below the boiling point, and then distilled for an hour. The ammonia evolved is titrated as usual. If you have time I would like to have the pepsin-hydrochloric acid method tried also.

Proceed as follows: Weigh 1 gram of sample into a 150 cc flask and add 100 cc of pepsin-hydrochloric acid solution.

This solution is prepared by mixing 5 grams of Parke and Davis's pulverized pepsin (guaranteed to dissolve 3,000 times its weight of freshly coagulated egg albumen) in 1,000 cc. of hydrochloric acid diluted to a strength of 1 per cent.

The flasks are then kept for twenty-four hours loosely corked in a water bath, having a constant temperature of 40° C. At the end of the second, fifth, eighth, and eleventh hours, 2 cc of a 10 per cent hydrochloric acid solution are added, shaking the flask thoroughly at the same time.

After twenty-four hours' digestion, filter, wash four or five times, using 20 to 30 cc of water for each washing, and determine nitrogen by the Kjeldahl method in the washed and dried residue.

Please let me know your results as soon as possible.

Yours truly,

F. S. SHIVER, *Referee on Nitrogen.*
W. R. PERKINS, *Associate Referee.*

I.

We consider first the determinations of total nitrogen by the Kjeldahl method.

(A) *Total nitrogen by Kjeldahl method.*

TABLE 1.—*Results on total nitrogen by the different analysts.*

Analyst.	Cotton-seed meal.	Ground fish.	Dried blood.	Tankage.	Ground bone.	Hoof meal.	Garbage fertilizer.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
T. C. Trescot, Department of Agriculture...	6.61	8.69	[1]12.67	6.49	[1]3.31	[1]14.26	3.16
J. A. Bezzell, North Carolina station.......	6.79	8.81	13.66	6.51	3.55	14.70	3.20
A. T. Eskridge, jr., Virginia station........	6.79	[1]8.37	[1]13.05	[1]6.29	3.76	14.40	3.06
F. B. Carpenter, Richmond, Va	6.90	8.96	13.72	6.50	3.61	14.78	3.20
J. P. Street, New Jersey station............	6.74	8.80	13.60	6.65	3.40	14.47	3.20
J. W. Ames, Ohio station..................	....	8.79	[1]13.29	6.45	3.33	14.33	3.13
W. R. Perkins, Mississippi station..........	6.55	8.78	13.47	6.50	[1]3.25	14.49	3.11
C. H. Jones, Vermont station..............	6.78	8.79	13.69	6.59	3.39	14.66	3.23
F. S. Shiver, South Carolina station........	6.85	8.81	13.85	6.40	3.68	14.94	3.26
Average..............................	6.75	8.80	13.66	6.51	3.58	14.59	3.17

[1] Omitted from the average.

The results in Table I are all by the Kjeldahl method, with the exception of those reported by Messrs. Trescot and Ames, which were obtained by the Gunning method.

These results, in so far as they apply to the cottonseed meal, ground fish, tankage, and garbage fertilizers, are quite satisfactory. The results on blood, ground bone, and hoof meal are quite variable. While these samples were not ground quite as fine as they could have been, yet it does not seem possible to explain the differences on that ground. I myself had no trouble in obtaining closely concordant results in duplicates, and in fact none seemed to have had any difficulty in this direction, judging by the results in my hands.

In regard to the blood and hoof meal, in which large quantities of nitrogen are present, I would say that I believe that the low percentages found by some are due no doubt to one of two causes: (1) To insufficient digestion. I think it has been pretty well established that unless the digestion be continued for some time after the solution has lost its color, the results obtained are too low. I myself have noticed this in the case of cottonseed meal, and Gerlach and others have called attention to the same thing. (2) To an insufficient amount of acid in the receiver in which the ammonia evolved is caught.

Unless a considerable amount of acid above that necessary for saturating the ammonia be present, a loss is sustained also. In the case of the sample of blood here, in the first analysis, I used a very small excess of acid, and in the second analysis I used a considerable excess, with the result that about four-tenths more of nitrogen were found than in the first analysis.

It is evident from these results that even with an old-established method, like the Kjeldahl, great care is to be exercised in the preliminary digestion with sulphuric acid, and also in the manner in which the ammonia evolved is received.

(B) *Digestion of organic nitrogen by the alkaline permanganate method* (Jones).

This method has been described in the letter of instructions quoted already.

Table 2 gives the results obtained by the different analysts with this method. This table gives the percentages of nitrogen evolved:

TABLE 2.—*Results on digestion of organic nitrogen with alkaline permanganate of potash (Jones).*

Analyst.	Cotton-seed meal.	Ground fish.	Dried blood.	Tank-age.	Ground bone.	Hoof meal.	Gar-bage ferti-lizer.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
T. C. Trescot, Department of Agriculture ..	2.50	5.79	7.35	3.70	[1] 2.02	9.84	0.65
J. A. Bezzill, North Carolina station	[1] 3.28	5.96	9.74	[1] 4.28	2.38	11.17	0.76
A. T. Eskridge, jr., Virginia station	2.66	5.50	9.04	3.79	2.58	11.32	0.67
J. P. Street, New Jersey station	2.82	5.62	9.57	3.70	2.49	10.64	0.51
J. W. Ames, Ohio station	....	5.76	8.26	[1] 0.89	[1] 0.44	[1] 10.96	....
W. R. Perkins, Mississippi station	2.73	[1] 4.24	8.57	3.39	2.25	8.42	0.73
C. H. Jones, Vermont station	2.96	[1] 5.21	8.66	3.50	2.31	9.08	0.60
F. S. Shiver, South Carolina station	2.78	6.01	9.63	[1] 4.08	[1] 2.89	....	0.67
Average	2.74	5.77	....	3.61	2.40	....	0.65

[1] Omitted from the average.

The figures in this table are somewhat variable, especially as regards the dried blood and hoof meal, for which reason I have made no attempt to give averages for these materials.

From the results in my hands it appears that many of the analysts experienced difficulty in securing concordant results by this method.

For myself, I would say that some of the results obtained by me were very unsatisfactory. In carrying out this method everyone must be impressed with the difficulties involved in keeping conditions the same in all cases. With the small amount of liquid (100 cc) used it is very difficult to prevent the solution from boiling in the preliminary digestion. Moreover, in the subsequent digestion I perceived great difficulty, in some cases at least, in preventing excessive bumping. This was especially true of the digestion of the dried blood and hoof meal.

In some cases I used pumice to prevent this bumping, but found this ineffectual.

Table 3 gives the percentages of availability of organic nitrogen, as determined by the alkaline potassium permanganate method (Jones). This data was secured by using the figures given in Tables 1 and 2.

TABLE 3.—*Availability of organic nitrogen by the alkaline permanganate of potash method (Jones).*

Analyst.	Cotton-seed meal.	Ground fish.	Dried blood.	Tankage.	Ground bone.	Hoof meal.	Garbage fertilizer.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
T. C. Trescot, Department of Agriculture	37.82	66.62	[1] 58.01	57.01	[1] 61.02	69.00	20.56
J. A. Bizzell, North Carolina station	[1] 48.30	67.65	71.30	[1] 64.97	67.04	75.98	23.75
A. T. Eskridge, jr., Virginia station	39.17	65.71	69.27	60.25	68.61	78.61	21.89
J. P. Street, New Jersey station	41.83	63.86	70.36	55.63	73.23	73.53	[1] 15.93
J. W. Ames, Ohio station	....	65.63	62.15	[1] 13.79	[1] 13.21	76.48	....
W. R. Perkins, Mississippi station	41.67	[1] 48.29	68.62	52.15	69.23	[1] 58.10	23.47
C. H. Jones, Vermont station	43.65	[1] 59.27	68.25	53.11	68.14	[1] 61.59	[1] 18.40
F. S. Shiver, South Carolina station	40.58	68.21	69.53	[1] 63.75	[1] 78.53	....	20.55
Average	40.78	66.28	67.06	55.63	69.25	74.72	22.04

[1] Omitted from the average.

The figures in this table are fairly satisfactory, with the exception of those given for tankage and ground bone.

An inspection of the figures, however, reveals one striking defect at least in this method. That defect is that this method fails to express the true relative availability of the nitrogen contained in cotton-seed meal. We might expect from this table cotton-seed meal to be a very inferior product, while on the other hand experience in the field has proven exactly the contrary.

Moreover, from this table we might expect ground bone to be a great deal more available than tankage or dried blood, a fact which is contrary to the results of practical experience.

With the mention of these objections to the method, which appear fatal to my mind, I invite your attention now to the consideration of the results obtained by the neutral permanganate process (Street).

(C) *Digestion of organic nitrogen by the neutral permanganate method.*

This method has been described in the letter of instructions, already quoted.

Table 4 gives the results obtained by the different analysts with this method.

The results given in this table refer to the percentage of nitrogen contained in the residue (insoluble nitrogen):

TABLE 4.—*Results on digestion of organic nitrogen with neutral permanganate of potash (Street).*

Analyst.	Cotton-seed meal.	Ground fish.	Dried blood.	Tankage.	Ground bone.	Hoof meal.	Garbage fertilizer.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
T. C. Trescot, Department of Agriculture	1.66	0.84	1.08	[1] 1.28	1.31	[1] 1.54	1.64
J. A. Bizzell, North Carolina station	1.45	0.78	0.69	0.73	0.93	0.87	1.57
J. P. Street, New Jersey station	1.36	[1] 1.20	0.65	[1] 1.55	[1] 1.61	[1] 1.59	1.79
J. W. Ames, Ohio station	....	0.65	0.66	0.93	1.44	[1] 1.40	1.72
W. R. Perkins, Mississippi station	1.52	0.78	0.82	0.96	1.33	0.92	1.57
C. H. Jones, Vermont station	1.47	0.56	[1] 0.27	1.05	[1] 2.45	0.77	....
F. S. Shiver, South Carolina station	1.44	0.50	[1] 0.30	0.71	1.14	0.84	1.55
Average	1.48	0.67	0.77	0.87	1.23	0.85	1.64

[1] Omitted from the average.

The results by this method are quite satisfactory, on the whole. The results on the cotton-seed meal, ground fish, and garbage fertilizer are very uniform. Practically everyone seemed to secure good duplicates with the method. I myself secured excellent duplicates with all the samples except the cotton-seed meal. My figure given above for the cotton-seed meal is the mean of two results, which did not agree as well as I wished, but lack of time prevented me from doing any more work with the sample.

I should like to call attention here to the necessity of determining nitrogen in the paper used for filtration in this method. In my work I used Schleicher and Schüll's folded filters, No. 258, 18½ centimeters. Two blank determinations were made on the paper in question, and as a mean of these determinations 0.0016 gram of nitrogen was found. All my results were corrected for this amount of nitrogen in the papers.

This seems at first sight quite a small amount of nitrogen, and so it is; but when we calculate availability this amount of nitrogen would alter figures considerably, and hence must be taken into consideration.

Table 5 gives the availability of organic nitrogen, as determined by the neutral potassium permanganate method (Street). In the preparation of this table use was made of the data obtained in Tables 1 and 4:

TABLE 5.—*Availability of organic nitrogen by the neutral potassium permanganate method (Street).*

Analyst.	Cotton-seed meal.	Ground fish.	Dried blood.	Tankage.	Ground bone.	Hoof meal.	Garbage fertilizer.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
T. C. Trescot, Department of Agriculture..	74.88	90.33	91.87	80.27	60.42	89.20	48.10
J. A. Bizzell, North Carolina station........	78.64	91.71	94.94	88.78	[1] 73.80	94.08	50.93
J. P. Street, New Jersey station	79.82	[1] 86.36	95.22	[1] 76.69	52.64	89.01	44.06
J. W. Ames, Ohio station..................	....	92.60	95.03	85.58	56.75	90.23	45.04
W. R. Perkins, Mississippi station..........	76.79	91.11	93.91	85.38	59.07	93.65	49.51
C. H. Jones, Vermont station...............	78.31	93.62	98.02	84.06	[1] 27.72	94.74	....
F. S. Shiver, South Carolina station........	78.97	94.32	97.83	86.40	[1] 69.02	94.37	52.45
Average..............................	77.73	92.28	95.26	85.07	57.22	92.18	48.34

[1] Omitted from the average.

The results here again are very encouraging, when we take into consideration the fact that very small differences in the percentages of nitrogen found make comparatively large differences when calculated to percentages of availability. From all these results I think we can say that this method is very promising; promising, not only because of the uniformity of the results obtained by its use, but also because of the agreement of these results with those of vegetation tests.

(D) *Results obtained on digestion of organic nitrogen with pepsin-hydrochloric acid.*

This method, too, has been described in the letter of instructions already quoted. Only one analyst, Mr. T. C. Trescot, U. S. Department of Agriculture, has found time to comply with my request in regard to this method. Your referee, I am sorry to say, was unable to do any work with this method for lack of time.

Table 6 gives the results on digestion of organic nitrogen with this method by Mr. Trescot.

The figures refer to the percentages of nitrogen found in the insoluble residue (insoluble nitrogen).

TABLE 6.—*Results on digestion of organic nitrogen with pepsin-hydrochloric acid.*

Analyst.	Cotton-seed meal.	Ground fish.	Dried blood.	Tank-age.	Ground bone.	Hoof meal.	Garbage fertilizer.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
T. C. Trescot, Department of Agriculture ...	0.65	1.83	0.42	1.84	0.22	10.22	1.62

Table 7 gives the percentages of availability of organic nitrogen as determined by this method.

This data was obtained by using the figures in Tables 1 and 6.

TABLE 7.—*Availability of organic nitrogen by the pepsin-hydrochloric acid method.*

Analyst.	Cotton-seed meal.	Ground fish.	Dried blood.	Tank-age.	Ground bone.	Hoof meal.	Garbage fertilizer.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
T. C. Trescot, Department of Agriculture..	90.16	84.69	96.60	71.64	93.85	28.33	48.73

By comparing these figures with the figures obtained for the availability of organic nitrogen by the Street method (Table 5) we find that there is a very close agreement between the figures for dried blood and garbage fertilizer, as obtained by the two methods. We find also that while the pepsin method only shows an availability of 28.33 per cent for hoof meal, the Street method shows an availability of 92.18 per cent, which agrees much better with the figures obtained by vegetation tests.

As the merits and demerits of the pepsin method have been considered already in the first part of this paper we will desist from any further consideration of the same here.

II.

After having sent the samples out to all those who had signified their intention of cooperating with me in the work, I received a letter from Mr. J. P. Street, of the New Jersey Station, who said he thought better results would be secured if the samples were ground finer. As I have said previously, all the samples were ground, as the association directs, to pass a sieve having circular perforations 1 millimeter in diameter.

Nevertheless I wrote Mr. Street, and subsequently all others who had received samples, to first make the determinations suggested in my letter of instructions on the samples as received, and then to regrind them so as to pass a sieve having 50 meshes to the inch, and make all the determinations suggested again on this reground material. Three analysts have complied wholly or in part with this request.

Table 8 gives the results on digestion of organic nitrogen with alkaline permanganate on the samples reground as directed. These figures represent the percentages of nitrogen evolved.

TABLE 8.—*Results on digestion of organic nitrogen by alkaline permanganate of potash (Jones) after regrinding.*

Analysts.	Cotton-seed meal.	Ground fish.	Dried blood.	Tank-age.	Ground bone.	Hoof meal.	Garbage fertilizer.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
T. C. Trescot, Department of Agriculture...	2.30	5.43	7.35	3.44	2.05	10.56	0 61
J. P. Street, New Jersey Station............	2.76	5.64	9.54	3.68	2.47	11.29	0.72
C. H. Jones. Vermont Station	3.18	5.50	9.54	3.70	2.45	10.16	0 63

The results in all cases (except Mr. Trescot's) are somewhat higher.

Table 9 gives the results on digestion of organic nitrogen by neutral permanganate on the samples reground as directed. The figures refer to percentages of nitrogen in the residue.

TABLE 9.—*Results on digestion of organic nitrogen by neutral permanganate of potash (Street) after regrinding.*

Analyst.	Cotton-seed meal.	Ground fish.	Dried blood.	Tankage.	Ground bone.	Hoof meal.	Garbage fertilizer.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
T. C. Trescot, Department of Agriculture.	2.84	0.87	1.16	1.18	1.19	0.90	1.97
J. P. Street, New Jersey Station	1.45	1.01	0.78	1.18	1.10	1.15	1.79

Mr. Trescot's figures on the whole are higher; Mr. Street's lower.

Table 10 gives the results on digestion of organic nitrogen by the pepsin-hydrochloric acid method on the reground samples. The figures here refer also to the percentage of nitrogen in the residue.

TABLE 10.—*Results on digestion of organic nitrogen with pepsin-hydrochloric acid, after regrinding.*

Analyst.	Cotton-seed meal.	Ground fish.	Dried blood.	Tankage.	Ground bone.	Hoof meal.	Garbage fertilizer.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
T. C. Trescot, Department of Agriculture..	0.77	1.33	0.48	1.98	0.21	9.85	1.59

The results here are about the same, with the exception of the hoof meal, which is considerably lower.

Increased grinding, therefore, augments to a slight degree the nitrogen availability, and hence it may be well to have it understood that in the future all work of this character must be done on samples which have passed a sieve having 50 meshes to the inch.

This increased grinding, however, it must be understood is not necessary in order to secure uniform results, as this can be accomplished on coarser samples, as shown by the results in this paper.

In conclusion I desire to express my appreciation of the efforts of all those who have assisted me in this work, and also to apologize to the association for the incomplete report here submitted.

I desire further to thank the association for the honor it has allowed me of serving it for two years in the capacity of associate referee on nitrogen. I hope my efforts have not been entirely unappreciated.

RECOMMENDATIONS.

I would recommend that the neutral permanganate of potash method (Street) be referred to the referee on nitrogen for 1900 for further trial.

All of which is respectfully submitted.

The CHAIRMAN. The report on potash by Mr. B. B. Ross, of North Carolina, is next in order.

Mr. WILEY. I have Mr. Ross's paper which I will read. I will first read a letter which I have received from him.

ALABAMA POLYTECHNIC INSTITUTE,
Auburn, June 28, 1899.

Dr. H. W. WILEY,
Secretary Association of Official Agricultural Chemists, San Francisco, Cal.

DEAR DR. WILEY: I herewith inclose my report on potash, which was prepared under great difficulties and in great haste, owing to the press of work on hand at present.

The analytical data presented are somewhat meager, and some of the results arrived so late that it is impossible for me to tabulate them in time to have them manifolded.

The results I send are averages as reported by each analyst, and in this form they can be placed on a blackboard easily. I will send fuller results to you at Washington, but trust these will answer the purposes of the association.

In accordance with your suggestion, I include with my report a review of the potash work of the association up to this time, though it is quite possible that I have overlooked some points of interest.

With kindest regards to the members of the association, including yourself, and regretting that I can not be present at the San Francisco meeting, I am,

Yours, very truly,

B. B. ROSS.

P. S.—At last moment was unable to average results.

REPORT ON POTASH.

By B. B. ROSS, *Referee.*

At the suggestion of the secretary of this association, the referee presents, in connection with his report on potash, a short résumé of the work on this subject performed by the association since its inception fifteen years ago.

As is known to many, the organization of this association was preceded by a convention of agricultural chemists which was held in Atlanta in May, 1884, and although methods for the determination of phosphoric acid were adopted, no action was taken with regard to potash methods. The minutes of this meeting, however, indicate that the subject was discussed to some extent, and if we are to judge from the reports of the discussions, some very crude methods of potash determination were in use in some of the laboratories at that time.

Several years prior to this time a convention of agricultural chemists was held in Washington (July 28, 1880), and the following method for the determination of potash in fertilizers was recommended: "Solution in water, removal of sulphates, phosphates, and magnesia by barium hydrate, clearing with oxalate or carbonate of ammonia and precipitating with platinum chloride."

This method, whose brevity allowed considerable latitude for the individual analyst, was essentially the same as that followed in many laboratories in this country prior to the organization of this association, though in most cases barium chloride was employed as a precipitant in connection with barium hydrate.

At the first meeting of the association in Philadelphia, in 1884, methods for potash as well as phosphoric acid were adopted, the process for the determination of the former in fertilizers corresponding closely with the present optional method, although hydrochloric acid was employed along with water in effecting the solution of potash, and the method also differed in the particular that neither oxalic acid nor ammonium oxalate was employed in the precipitation of lime, and two separate treatments with ammonium carbonate were required, accompanied by an additional filtration, evaporation, and ignition.

At the Philadelphia meeting, Dr. H. W. Wiley was appointed chairman of the committee on potash, and at the first Washington meeting thereafter presented a most comprehensive report, reviewing all of the methods of importance for potash determination in use at that time, and also calling attention to various methods which had been proposed during the few years preceding. In this report attention was called to the fact that the method described by Stohmann about twenty years before, and extensively employed in Germany in the analysis of crude kainit, is essentially the same as that which found its way into use as the first official method of this association.

A reference to the report alluded to reveals the fact that the unification of methods of analysis in the different countries had made but little progress, and the methods in use in any given country for commercial work showed wide divergences as regards details, even where the methods involved the same principle.

As early as 1875 steps had been taken by the British Association for the Advancement of Science looking toward the securing of uniformity in methods of analysis of fertilizing materials, and a commission appointed for the purpose endeavored to secure from the leading chemists engaged in commercial analysis a statement as to the methods employed in their laboratories for potash and phosphoric acid work. They were not altogether successful, however, in their request for information of this character, as one prominent firm of commercial chemists declined to give the information desired, "as we do not think ourselves called upon to publish our methods of analysis, which we have perfected after long and careful investigation, for the benefit of those who have not taken this trouble." Fortunately chemists of this character are the exception rather than the rule, and the committee referred to, as well as the Society of Public Analysts, have been able to do much toward the harmonizing of diverse methods of analysis in spite of opposition from such sources. As the result of the work of this committee, the process of Wallace, Tatlock, and Clark was brought into notice (Chem. News, XXXII, 201), the prominent feature of this method being the washing of the double chloride of potassium and platinum with a solution of platinum chloride.

The report of Dr. Wiley in the proceedings of the second annual convention of the Association of Official Agricultural Chemists covers the literature of potash determinations up to that time so thoroughly that it is unnecessary to refer to the processes in use prior to that date In this report he refers to the process proposed by David Lindo, which was the basis of our present official method. The method of Lindo was first communicated to the scientific public through the Chemical News in 1881, and for several years failed to attract any considerable attention from analytical chemists.

The method was originally proposed for the determination of potash in crude potash salts, and was especially designed to overcome the difficulties attendant upon the determination of potash when present as sulphate, or in the presence of sulphates of other metals. At the meeting in 1885 Mr. Thomas S. Gladding presented a paper in which were embodied results of tests of Lindo's original method, and in connection therewith he submitted a modified method applicable to mixed fertilizers. This method was printed in the proceedings of the convention for the year referred to, but was not adopted as an optional or alternate method until the following year.

At the convention of 1885 Dr. Wiley, as chairman of the potash committee, reported the results of some very valuable cooperative work on potash determinations carried out under the direction of that committee, and as a result of these investigations the use of hydrochloric acid as a solvent in potash work was discontinued, and the employment of oxalic acid or ammonium oxalate in connection with ammonia and ammonium carbonate was recommended, the second evaporation and ignition after the use of ammonium carbonate being dispensed with.

In 1886 the Lindo-Gladding method was subjected to comparative tests along with the official method, although only a small proportion of the analysts taking part in the potash work made determinations by the new process. The results presented, however, were quite satisfactory, and the Lindo-Gladding process was given a place as an alternate method, while the leading feature of this process was further recognized in the provision made in the official method for the use of ammonium chloride wash water in case of the contamination of precipitates obtained by what was then the regular method. The new method was given a further and quite comprehensive trial in 1887, and was adopted as the regular official method, while the former official process was relegated to the place of an alternate method.

The method of Lindo, as originally modified by Gladding, provided simply for the addition of ammonia before making solution up to the mark, but in 1888, upon recommendation of Mr. E. B. Voorhees, of the New Jersey Station, the addition of ammonium oxalate to effect the complete precipitation of lime was also required.

During the succeeding two years no changes of importance were made in the methods of potash determination, although in 1891 the process was so modified that ammonia was added before the ammonium oxalate in the official method, and the addition of the latter reagent was made to the hot solution instead of adding it to the solution after cooling. At this meeting of the association a paper was presented by Mr. A. L. Winton, of the Connecticut Station, with reference to the desirability of omitting the use of sodium chloride from the Lindo-Gladding method, and numerous results were reported in support of the contention that the employment of this substance was unnecessary. This question was further tested under the direction of Dr. G. F. Payne, reporter on potash for 1892, and as the result of numerous cooperative determinations the use of sodium chlorid was discontinued. As before stated the employment of sodium chloride was proposed by Gladding in his original modification of the method of Lindo, but the use of sodium chloride in the determination of potash in the presence of sulphates had been proposed by Wallace, Tatlock, and Clark as early as 1875. (Chem. News, 32, 202.)

At the 1891 meeting, the method for kainit was so changed as to require the use of ammonia and ammonium oxalate to precipitate lime, and an additional evaporation and ignition was thus entailed upon those employing this method. This change was made without any request therefor by the reporter, and without any previous investigation into the desirability of such a change. Some two years since, upon the recommendation of Mr. Winton, the referee on potash at that time, the association dispensed with the use of ammonia and ammonium oxalate, and returned to the use of the method as originally employed.

In 1893, for the first time, the cooperation of European chemists was secured in the determination of potash in association samples, but the results of this cooperative work were of comparatively little value, for the reason that the foreign chemists employed the German official methods and the Stassfurt method, while American chemists likewise confined themselves to the use of American official methods.

During the past few years Messrs. Wheeler and Winton, as referees on potash, have tested the accuracy of both the Lindo-Gladding and optional methods quite thoroughly by the employment of chemically pure potash salts, mixed with varying proportions of the impurities commonly met with in the crude potash salts. Cooperation on the part of German chemists was also secured to a limited extent in testing the comparative merits of the Lindo-Gladding and Stassfurt methods, and the Stassfurt method has also been given an official trial by this association, with results not at all disadvantageous to our present official method.

Winton has shown by results of experiments reported to the association that a very common source of error in potash determinations is the retention of mother liquor in the interior of crystals of the double chloride, especially when these crystals are at all large, and on this account has recommended that the drying be effected at 130° C., or else that the precipitation be effected from dilute solutions.

As the result of investigations made and reported some two years since, the factor now employed for the calculation of the amount of potassium oxide is 0.1939 instead of the factor 0.19308 formerly in use.

The abstract committee has furnished the association with information with regard to new methods of fertilizer analysis proposed by foreign workers, and it would be useless to refer in detail to the various processes proposed in the time elapsing since the résumé of potash methods was presented in the proceedings of the second annual convention.

The perchlorate method has attracted considerable attention from foreign chemists within the past few years, and in a recent number of the Journal of the American Chemical Society (January, 1899) Mr. F. S. Shiver presents the results of an investigation made by him with regard to the advantages of this process as compared with other methods.

The perchlorate method, however, is not a new method in principle, having been employed by Schloesing, Henry, and others nearly thirty years ago, though, by reason of certain improvements in the details of the process, it has become more easy of execution, and is held in high esteem in many of the European laboratories.

Numerous processes have been proposed by Borntraeger, Jean and Trillat, Ehrmann, Villiers, Borg, and others for the reduction of the chloro-platinate by means of various agents, the spongy platinum being weighed instead of the double chloride; but none of these processes seems to be free from objections with regard to its use as an independent method.

POTASH WORK FOR 1899.

The early date at which the association convenes this year and the large amount of work devolving upon the referee during the spring and early summer months have led to the contraction of the scope of the work on potash for the present year. Much to my regret, some features which it was intended should be included in the investigation of potash methods were, at the last, eliminated from the plan of work outlined for the present season and the work was restricted to limits commensurate with the time at the disposal of the referee and the cooperating chemists.

During the past spring a circular letter was sent out to about sixty laboratories with a view to securing cooperation on the part of the chemists addressed in the investigation of methods of potash determination. In reply to this letter twenty-five chemists requested samples, several of whom, however, agreed to do the work conditionally. The following letter of instructions was sent out with each set of samples:

Instructions for potash work for 1899.

In view of the fact that other features of the potash work have been covered quite fully during the past few years, it has been deemed desirable to prepare for distribution two samples which contain at least a portion of their potash in organic forms.

Sample No. 1 consists largely of acid phosphate mixed with ground tobacco stems, while an additional amount of potash is supplied as muriate. Sample No. 2 is composed chiefly of acid phosphate and cotton-seed meal, together with a small proportion of sulphate of potash.

The preparation of the solution for potash determinations should be effected according to the method usually employed for organic materials, 10 grams of the sample being saturated with strong sulphuric acid and thoroughly incinerated.

The referee would also suggest that parallel tests be made with employment of sulphuric acid diluted 1:1 (one to one) for saturation of the material preparatory to ignition. The acid thus diluted moistens the material much more thoroughly than a corresponding amount of the concentrated acid, and after drying the sample slightly on an asbestos board it can be quickly incinerated in a muffle or over the direct flame with less difficulty than where the strong acid is employed.

It is desired that results be reported both by the Lindo-Gladding and the optional methods, and the statement of results should show the amount of substance employed in the determination, the total weight of K_2PtCl_6 obtained, and the weight of K_2PtCl_6 from blanks.

It was suggested at the last meeting of the Association of Official Agricultural Chemists that all weighings by the Lindo-Gladding method should be made in the Gooch crucible, and it is requested that comparative tests of results by the use of the Gooch crucible and the tared filter be made (by the Lindo-Gladding method), the precipitate being dissolved on the filter paper with hot water in order to check results.

It is also desired that moisture in the samples be determined.

Results should reach the referee not less than fifteen days in advance of the next meeting of the association, in case said meeting is held in July, or thirty days in advance of the meeting, in case the convention is held in the fall.

Respectfully,

B. B. Ross, *Referee.*
L. S. Munson, *Associate.*

The two samples sent out for analysis were prepared as follows:

Sample No. 1 consisted of an intimate mixture of acid phosphate, finely ground tobacco stems, chemically pure potassium chlorid, and chemically pure magnesium sulphate, in the following proportions: 82 ounces of acid phosphate, 64 ounces of tobacco stems, 10 ounces of potassium chlorid, 4 ounces of magnesium sulphate.

Sample No. 2 was prepared by mixing the following ingredients in the proportions named: 84 ounces of acid phosphate, 64 ounces of cotton-seed meal, 8 ounces of potassium sulphate, 4 ounces of magnesium sulphate.

In both cases the constituents of the mixture were finely pulverized and intimately mixed with each other. Careful analyses made in the laboratory of the Alabama Station showed the tobacco stems to contain approximately 9.62 per cent potash, while the cotton-seed meal showed a content of 2.04 per cent potash. Calculated upon this basis, sample No. 1 should contain about 7.80 per cent potash, and sample No. 2 about 3.52 per cent potash.

Reports were received from seven laboratories exclusive of the Alabama laboratory, and the appended table of results represents the work of twelve analysts in eight laboratories.

Results upon sample No. 1.

Analyst.	Moisture.	Lindo-Gladding method.		Optional method.	
		Incineration with concentrated acid.	Incineration with dilute acid.	Incineration with concentrated acid.	Incineration with dilute acid.
W. A. Rawls, Florida	....	[1]7.77	7.75		
		[2]7.70			
		7.74			
Thorn Smith, Idaho	7.74	7.99	7.78		
		7.97	7.78		
			7.78		
		7.99			
		7.98			
		7.98			
		7.98			
R. E. Blouin, Louisiana	....	[2]7.85	[2]7.82	[2]7.80	[2]7.84
J. S. Carroll, Mississippi	6.82	7.90			
		7.94			
		7.85			
		7.88			
		7.89			
J. L. Stinson, Mississippi	6.82	7.84	7.90		
		7.87	7.92		
			7.91		
		7.85			
		7.82			
		7.84			
R. F. Hare, New Mexico	7.27	7.85	7.89	....	7.68
C. D. Harris, North Carolina	9.11	7.70	7.79		
		7.88	7.73		
		7.79			
			7.88		
			7.66		
			7.77		

[1] Used Gooch crucible.

[2] Used tared filter.

Results upon sample No. 1—Continued.

Analyst.	Moisture.	Lindo-Gladding method.		Optional method.	
		Incineration with concentrated acid.	Incineration with dilute acid.	Incineration with concentrated acid.	Incineration with dilute acid.
F. B. Carpenter, Virginia	....	7.78 7.80 — 7.79			
R. G. Newborne, Virginia	....	7.69			
J. Q. Burton, Alabama	8.23	....	7.88 7.95 — 7.91		
B. B. Ross, Alabama	....	....	[1] 7.82 [2] 7.85 — 7.84	....	7.89
Means	7.78	7.82	7.82	7.80	7.80

[1] Used Gooch crucible.

[2] Used tared filter.

Calculated potash content, 7.80.

Results upon sample No. 2.

Analyst.	Moisture.	Lindo-Gladding method.		Optional method.	
		Incineration with concentrated acid.	Incineration with dilute acid.	Incineration with concentrated acid.	Incineration with dilute acid.
W. A. Rawles, Florida	....	[1] 3.64 [2] 3.65 — 3.64	3.68		
Thorn Smith, Idaho	7.92	3.56 3.56 — 3.56	3.41 3.41 — 3.41		
R. E. Blouin, Louisiana	....	[2] 3.28	[2] 3.29	[2] 3.28	[2] 3.30
J. S. Carroll, Mississippi	5.92	3.34 3.35 3.38 3.32 3.30 3.38 — 3.35	3.32 3.31 3.30 — 3.31		
J. L. Stinson, Mississippi	5.92	3.37 3.34 3.29 3.31 3.28 — 3.32	3.35 3.30 3.34 3.30 3.29 3.34 — 3.32		
R. F. Hare, New Mexico	4.75	3.61	3.74		
C. D. Harris, North Carolina	8.70	3.40 3.50 — 3.45	3.50 3.50 3.55 3.47 3.37 — 3.48		
F. B. Carpenter, Virginia	....	3.41 3.40 — 3.40			

[1] Used Gooch crucible.

[2] Used tared filter.

Results upon sample No. 2—Continued.

Analyst.	Moisture.	Lindo-Gladding method.		Optional method.	
		Incineration with concentrated acid.	Incineration with dilute acid.	Incineration with concentrated acid.	Incineration with dilute acid.
R. G. Newborne, Virginia		3.42			
		3.41			
		3.41			
J. Q. Burton, Alabama			3.64		
			3.74		
			3.69		
C. L. Hare, Alabama	6.01		[1] 3.62		3.60
			[1] 3.61		3.54
			[2] 3.55		3.57
			[2] 3.58		
			3.59		
B. B. Ross, Alabama			[2] 3.46		
			[2] 3.51		
			3.48		3.38
Means	6.66	3.45	3.49	3.28	3.42

[1] Used Gooch crucible.

[2] Used tared filter.

Calculated potash content, 3.52.

COMMENTS OF ANALYSTS.

C. D. Harris, North Carolina.—All weighings were made in Gooch crucibles. I found that the time required for incineration was considerably shortened by using the 1 to 1 acid.

R. E. Blouin, Louisiana.—All weighings were made on balanced filters.

J. S. Carroll and J. L. Stinson, Mississippi.—In sample No. 1 low results were obtained when saturated with 5 or 6 cc dilute sulphuric acid, but good results when 10 cc were used. In sample No. 2, 5 cc of dilute acid seemed to be sufficient. All weighings were made in Gooch crucibles.

R. F. Hare, New Mexico.—I am of the opinion that the dilute acid is better than the concentrated for treatment of the material, and think that a strength of 1 to 4 would be better still.

C. W. McCurdy and *Thorn Smith, Idaho.*—Used paper in bottom of Gooch crucible instead of asbestus. The difference in the results with concentrated acid and 1 to 1 acid I ascribe to insufficient acid in the latter case. While the material was completely saturated, I do not think that there was a sufficiency of acid. We find the concentrated acid fully as easy to apply, and prefer it. There was a uniform loss of 0.01 per cent in dissolving off the precipitate and reweighing filter.

In the laboratory of the Alabama Station it was found that ignitions after saturation with 1 to 1 acid could be effected much more rapidly and easily than with the concentrated acid, and it is also easier to detach the ignited residue from the dish.

The data with regard to the comparative merits of the Gooch crucible and the tared filter, as derived from these results, are so meager as to preclude the drawing of any definite conclusions for or against the use of the filter. While a very large proportion of our analysts will probably prefer to use the Gooch crucible, nevertheless the results as reported by the use of tared filters indicate that it is possible to secure quite satisfactory results by the employment of the latter process of filtration.

The association has already recommended that the optional method be not used when the potash is present as sulphate, and it would seem that the same objection would hold good when the fertilizers are incinerated with sulphuric acid.

The referee has recently made a number of determinations by a process which is being tested in the Alabama Station laboratory, and it is his intention to make further trial of the method referred to with a view to determining its accuracy and adaptability to regular fertilizer work. A very large proportion of our mixed fertilizers requires ignition after treatment with sulphuric acid, and during the process of incineration not only is the organic matter destroyed, but ammonia is also expelled. This end having been attained, it is desirable if possible to avoid another evaporation and ignition. To obviate this second ignition the residue in the dish is removed without addition of hydrochloric acid, rubbed up with a pestle, and transferred to a beaker. It is next boiled with 300 cc of water, as usual, and just before the conclusion of the boiling a small quantity of barium carbonate, suspended in water, is added and the boiling continued for a short time. The barium carbonate effects the precipitation of iron, alumina, some of the phosphates, and a part of the lime and magnesia. The solution after cooling is made up to 500 cc, an aliquot is filtered out, a few drops of hydrochloric added, and then an excess of platinum chloride. The process is then continued as in the Lindo-Gladding mehod, using ammonium chloride wash water.

Results by this process agree quite closely, so far as the method has been tested, with those obtained by a water solution by the regular Lindo-Gladding method, but the method has so far been tried to only a very limited extent.

The referee would call attention to the fact that the results by the Lindo-Gladding method for sample No. 1, if one determination be excluded, are within 0.2 per cent of each other, and that, too, in a sample of a complex character, and with a potash content so high as to make a slight variation of little moment. These results bear strong testimony to tne accuracy attainable with the use of our present official method in case of complex mixtures containing potash derived from a number of different sources.

RECOMMENDATIONS.

The referee does not feel justified in recommending any changes in our present methods for potash determinations, but would suggest that the use of 1 to 1 sulphuric acid be allowed as an option for saturating mixed fertilizers preparatory to ignition.

The CHAIRMAN. Next in order is the report on phosphoric acid, by E. G. Runyan, of the U. S. Department of Agriculture, Washington, D. C. Before we have that, if there are suggestions to be made or discussion to be had upon the recommendations of the reporter on postash, they will be in order.

Mr. WILEY. I think it is a matter of congratulation that the referee finds his conscience will not permit him to make any suggestions for changes in the method of analysis.

The CHAIRMAN. We will take up the method for phosphoric acid, by Mr. E. G. Runyan, of Washington, D. C.

Mr. Runyan presented the following paper:

REPORT ON PHOSPHORIC ACID.

By E. G. RUNYAN, *Referee.*

In response to requests for samples from analysts who expressed a willingness to take part in the work on phosphoric acid for this year, sixteen sets of samples, with instructions, were sent out to as many analysts, but when the date of the meeting was announced it was feared that few of the analysts would have the work completed and ready to report by that time. Such proved to be the case, as the only reports received up to the present time are from two labaratories, which report results on part of the work outlined and state that lack of time prevented their doing more. Under the circumstances it was not thought best to present these few figures here, but to give instead a brief history of the work on phosphoric acid by members of this association since its organization, which has led to the adoption of our methods in their present form.

Realizing the urgent need of chemical methods which would yield more concordant results at the hands of different analysts, a meeting was called of American chemists engaged in fertilizer analyses, which convened in Washington July 28, 1880, and was styled a convention of agricultural chemists.

A committee of five was appointed to select a method for determining phosphoric acid in commercial fertilizers. This committee recommended the adoption, provisionally, of a method based on that of Fresenius, Neubauer, and Luek. By this method the water soluble was determined by rubbing up the sample with water and washing until filtrate was no longer acid. The citrate insoluble was determined by rubbing up residue from water soluble with 100 cc neutral ammonium citrate solution, transferring to flask, placing flask in cold-water bath, and raising temperature to 40°, maintaining at that point half an hour, filtering, and washing with dilute citrate solution. The method for total was practically the same as the gravimetric method now in use.

At the Cincinnati meeting, in August, 1881, results obtained with phosphatic fertilizers by treatment according to the Washington method, and also results by the oxalate method were presented. In the general discussion the results by the Washington or citrate method were compared unfavorably to those by the oxalate method. The latter, it was claimed, gave higher available phosphoric acid.

After a lengthy discussion the convention decided to substitute ammonium oxalate for ammonium citrate as a solvent. By this method the insoluble was determined by treating the residue from the water soluble with 100 cc of a neutral solution of ammonium oxalate containing 20 grams of the salt to the liter, digesting in a boiling water bath for one hour, filtering, washing, and determining the insoluble in the residue by the usual method. This was known as the Cincinnati method.

Following this meeting a number of the chemists tested the Washington and Cincinnati methods on a set of samples sent out by the secretary. Strange to say, the results for available phosphoric acid by the oxalate were uniformly lower than by the citrate method. After these results were reported we find no further indorsements of the oxalate method, either by the convention of agricultural chemists or its successor, the Association of Official Agricultural Chemists.

At the Atlanta meeting, in May, 1884, a number of papers were presented giving results on the several forms of phosphoric acid according to the straight Washington method and modification thereof. These modifications were mostly variations in the temperature and time of treatment with citrate solution, and in the relative proportions of material and solvent.

The action of the convention in the adoption of a method for the ensuing year was practically a return to the Washington method, changing, however, the temperature of the bath used in the citrate digestion from 40° to 65°.

In September of the same year the convention of agricultural chemists met in Philadelphia and organized the Association of Official Agricultural Chemists.

The methods adopted by the convention at the Atlanta meeting were adopted as the official methods of the new association.

At the second annual meeting, in Washington, the following year, the committee presented averages of results obtained by fifteen analysts, with the highest and lowest results reported. A full discussion followed, but no important change in methods was made.

At the third annual meeting, in 1886, the committee reported results on soluble, insoluble, and total phosphoric acid. The results on total and soluble phosphoric acid were quite satisfactory, while the results on insoluble were extremely unsatisfactory.

Mr. Clifford Richardson presented a paper giving the results of some experiments in testing the delicacy of various indicators with ammonium citrate solution, and showed corallin to be more delicate than litmus for such work.

A paper was also presented giving results obtained in a comparison of Wagner's with the association method for the determination of available phosphoric acid. Wagner's method employs an acid solution of ammonium citrate.

The methods were changed to the extent of directing the use of corallin as an indicator in the preparation of the ammonium citrate solution.

In 1887 the committee on phosphoric acid presented results from only six analysts. While the results on the three forms of phosphoric acid were on the whole satisfactory, still the figures presented were considered too few to warrant making any changes in the methods.

In 1888 the committee presented results from thirty-two analysts. Some results were also contributed, obtained by experiments to test time required for complete precipitation. The figures given showed that in these tests the phosphoric acid was practically all precipitated by the molybdic solution in five minutes, and by the magnesia mixture in fifteen minutes.

One point brought out in the discussion which followed was that the variable quantity of water added each time to the phosphate in determination of soluble might be one cause of lack of uniformity. The association therefore directed that a Schleicher and Schüll No. 589 filter, 9 cm. in diameter, be used in the determination of water soluble, and that the phosphate be rubbed up in a beaker.

The methods were further slightly modified to the extent of allowing the use of either water or ammonium nitrate solution as a wash for the yellow precipitate.

The reporter in 1889 presented results from fifteen chemists. Most of these results were considered good. With each set of samples the reporter also sent 400 cc of ammonium citrate solution for comparison of tests for neutrality. One chemist reported this solution alkaline, while one reported it slightly acid.

The question of grinding and sifting the samples and size of sieve to be used came up for discussion, when it was found that wide differences existed in the practice of different laboratories. Therefore the association directed that the samples be passed through a sieve having circular perforations one twenty-fifth of an inch in diameter.

Following the report on phosphoric acid at the meeting in 1890, papers were presented emphasizing the facts that slight deviations from the neutral point of the citrate solution, variations in temperature, and relative proportions of material and solvent might cause wide differences in figures for citrate soluble, especially on phosphates of iron and alumina.

After an extended discussion the association modified the methods slightly by limiting the filtrate in the determination of water soluble to 250 cc and directing that the citrate insoluble residue be washed with water at 65°, instead of at ordinary temperature.

In 1891 the reporter gave considerable study to the action of various citrate solutions on phosphatic fertilizers, not only the official neutral solution, but acid and alkaline solutions as well.

In this connection he called attention to the fact that in working on fertilizers containing aluminum phosphate, some compounds containing phosphorus are either dissolved or carried through the paper when the citrate insoluble is washed with pure water, but when dilute citrate solution is used as the wash the filtrate is clear. It was suggested that in a case of this kind of material probably nearer correct results could be obtained by washing with cold, dilute citrate solution.

As a result of some experiments in the preparation of a neutral solution, the reporter presented a method which consists in the taking of a portion of the nearly neutral citrate solution prepared as usual and precipitating the citric acid with a neutral solution of calcium chlorid, filtering and testing neutrality of filtrate with cochineal. This was made an alternate method.

Early in the history of the association attention was called to the fact that with some classes of goods, especially cotton-seed meal, lower results were obtained when the organic matter was destroyed by a mixture of nitric and hydrochloric acids than when ignition was practiced.

Results obtained by trials of various methods on different fertilizing materials were presented at the meetings from time to time, and in 1891 much work was done along these lines and the data presented to the association. A thorough discussion followed and resulted in the adoption of the methods for oxidation of the organic matter and solution of the phosphate in practically their present form.

In 1893 the analysts were requested to determine insoluble by following strictly the official method, and also by modifying that method to the extent of heating the citrate solution to 65° before adding the phosphate. The results by the modified method were as a rule slightly lower, but they were much more concordant, and this modification was incorporated in the methods at the meeting in 1893.

At this meeting Prof. B. B. Ross gave a method for determining the citrate insoluble directly by destroying the organic matter in an aliquot portion of the ammonium citrate filtrate, preferably by digestion with sulphuric acid and mercuric oxid, and then proceeding as under determination of total phosphoric acid. The author gave a series of results obtained in his laboratory by this method, which showed close agreement with results determined by difference.

A comparison of this method with the official one was made by nearly all the analysts who took part in the phosphoric-acid work during the succeeding two years. The most of the results obtained were unsatisfactory.

While the results by the official gravimetric method were believed to be reliable, still the method is a long and tedious one, and analysts have long been looking for a method which would at least save one precipitation and at the same time give equally accurate results. To accomplish this various volumetric methods have been proposed, and in 1894 the reporter requested a trial of Pemberton's volumetric method, which depends upon the titration of the yellow ammonium-phospho-molybdate precipitate with a standard alkali solution. This method was later modified by Kilgore and also by McDonnell. Since 1894 an enormous amount of work has been done by members of this association in trials of this method and its various modifications.

The results at first obtained by many of the analysts were very discouraging, but later results were more concordant, and in 1895 they were considered promising enough to warrant the adoption of the Pemberton-Kilgore method as a provisional method. Further trials of this method were made and the results reported from year to year, and in 1898 the method was made an optional one.

A trial was made in 1896 and also in 1897 of Gladding's method of weighing the yellow precipitate, but the results reported by the members of this association did not show it to have any advantages over others already in use.

In anticipation of the sale in this country of large quantities of basic slags, members of this association have from time to time presented the results of their efforts in seeking a method for determining the available phosphoric acid in such material.

Of the many methods and solvents used in these trials, Wagner's method seems to be the only one that will give uniformly concordant results.

Interest in this work, however, seems to have declined lately, due largely to the small amount of this material which has found a sale in this country.

It has been claimed that the official gravimetric method gave too high results, due to excess of magnesia carried down by the ammonium-magnesium phosphate precipitate, and it was proposed to avoid this error by using a magnesia mixture containing citric acid in place of ammonium chlorid, or by adding ammonium citrate to the phosphate solution.

Trials were made of the proposed method in 1895 and in 1896. While the results were, as a rule, slightly lower than by the official gravimetric method, the proposed method was not considered to have any advantage over the official gravimetric method, especially as under some conditions the phosphate did not seem to be all precipitated.

Methods for the determination of iron and alumina have received the attention of this association, and results obtained by nearly all the latest methods have been presented at the meetings at various times, but up to the present none of the methods has been considered of sufficient merit to be indorsed as official.

It has been impossible, if advisable, in this review to mention all the papers and results on phosphoric acid presented at the meetings of this association, but it has been our aim to refer, however slightly, to all work which had a direct bearing upon a change or proposed change in the official methods for phosphoric acid.

Mr. WILEY. I would suggest that we have our meeting to-morrow morning after the general meeting of the association is finished, which will probably be about half-past 10. Therefore I move that we meet in this room to-morrow morning at half-past 10, and that the next meeting be held to-morrow immediately on the adjournment of the section on agriculture, so that we will have two meetings to-morrow. (Carried.)

Mr. KILGORE. I have a short paper on phosphoric acid, but I had no idea it would come up this afternoon. Moreover, the referee did not give us any results or recommendations. It might be well to get the opinions of men who report results as to how satisfactory the results were. At least one thing expected was the result of the comparison of the two methods.

Mr. RUNYAN. I am not prepared to give the exact figures sent in, but I received a report from Mr. Kilgore's station, and the only other figures received were from a commercial chemist, giving phosphoric acid on two samples, I think; so that I thought it hardly worth while to give them, and have not those figures with me.

Mr. KILGORE. I can give, in a very few words, the substance of the paper. Last year, in my report as referee on phosphoric acid, I took up the method of precipitation by shaking and did quite a good deal of work in that way. The main trouble, it seemed, that we had had with the volumetric method was that some of the nitric acid would be precipitated, and I tried various methods, as others had done, of preventing this, and while the method had given satisfactory results, still if we could precipitate in the cold I felt there would be no trouble, and, going back to the method of shaking as they do, we tried the shaking machine and found that precipitation was complete in all cases in fifteen minutes, though we let the machine run half an hour. As I say, we did quite a good deal of work last year in this line, and our results were all good. This year we have continued that again, and quite a large amount of work has been done in my laboratory by two or three men with shaking, and our results have all been good. In fact, in using the method in the future I think that shall be my procedure entirely. Now, we have not tried the shaking at a very low temperature, as some of you have, in the winter. Most of our work has been done in the spring or summer in a laboratory with a temperature of 20° to 30°, and our results that way have all been good. When a very large excess of molybdic solution is used you may get good results. We find we can not add a very large excess of molybdic solution without raising the results. The paper I had was upon this point. The paper I sent in was by both methods. We had also a large number of additional results.

Mr. Scovell. In the investigation of the volumetric method of analysis of phosphoric acid it has been my practice to add the phosphoric acid solution to the molybdic solution, then allow the mixture to stand at the temperature of the room from fifteen to thirty minutes before filtering. By this procedure the precipitate comes down in granular form, allowing a rapid filtration and obtaining a perfectly clear filtrate. Furthermore, our results indicate that by this method we may be able to obtain a precipitate of uniform composition—a condition which must obtain in order to have trustworthy results by the volumetric method.

In the meeting in Washington in 1897 I mentioned the possibility of an improvement in the method by the above procedure.

Mr. Wiley. Mr. President, it is rather strange that the mechanical method of shaking has not generally been brought into chemical work, because the principle seems to be so patent. You have in solution a substance which is diffused finely throughout the whole mass, and if crystallization takes place without motion it can only do so, first, by the solidification of the particles at a certain point, and then the gradual growth of the crystals. The theory of the movement is that the particles of matter, when formed, are at once brought into contact with the rest of the uncrystallized solution, so that they have a mechanical opportunity of precipitation. Now, that matter in technical work has been understood and acted upon—for instance, in the sugar industry. You know that in the sugar industry the first crystallizations are always secured in movement, because the movement of the boiling in the pan brings that about, and we get there magnificent crystallization. The old way in boiling molasses was to set the pans aside, sometimes for months, and to secure the crystallization, but now mechanical movement has been introduced, and a much larger crystallization is obtained. The molasses is kept in constant motion, and the result is the yield is far greater in a few hours or a day or two than before in weeks and months. The shaking secures a much more perfect separation, and I doubt not that a great many of our chemical operations could be greatly accelerated by applying this natural method. We ought not to allow the technicists to get ahead of us in our work.

I would like to announce that our next meeting will take place as soon as possible after the discussion of the "teaching of agriculture" in the general session of the American Association of Agricultural Colleges and Experiment Stations is finished, when we should at once repair to this hall and continue our work.

Adjourned.

SECOND DAY'S PROCEEDINGS.

The chairman (Mr. Kedzie) called the session to order, and stated that the first business would be the report of the referee on soils and ash, Mr. Hartwell, of Rhode Island.

Mr. Williams, of North Carolina, requested that the discussion on phosphoric acid, or papers upon that subject, be continued at this time, and the chair so directed.

Mr. **Williams.** I wish to state the results of our experiments. It was found that occasionally a fertilizer was encountered which was not dissolved by the usual method—that is, 30 cc nitric acid and 10 cc hydrochloric acid. It was found that in the solution it was not all dissolved. This was discovered by making determinations from the same solution one day, and a day or so after making the determination again, and it was found that the percentage of variance was considerable. We have found a difference as high as 5 per cent in the determination of phosphoric acid. In two samples worked on we worked for a number of hours. That is, we made the determination as soon as we could cool the sample—thirty-five minutes; and twenty-one hours after that we made another determination and got something like 5 per cent. In all these samples it was found that we had a large percentage of iron or aluminum. In two of the samples the percentage of ferric oxid was found as high as 19 and 24. We feel that this is very important, not only from the analytical standpoint, but from the practical standpoint. We see that in North Carolina the use of iron aluminum phosphates is coming into practice, and we see that we have a condition there that we must investigate.

The **Chairman.** Is there any other paper to be read or discussion desired on phosphoric acid?

Mr. **Kilgore.** I would like to ask if Mr. Williams tried hydrochloric acid alone for the solution. It appears that the trouble has come from making the solution in nitric acid. Apparently he has iron or aluminum phosphate to deal with, and I would like to ask what is the difficulty—whether he could not use the hydrochloric acid alone, which is one of our methods, recognized as the principal solvent in such cases. Last year, I know, in sending out slags as referee on phosphoric acid, some of the workers misunderstood the method indicated to be used, and tried this method Mr. Williams has employed, of using nitric and hydrochloric acid, and they had the same difficulty he has referred to.

The same question has come up again this year in regard to some of the other samples sent out. I know in my own laboratory they got the idea that nitric and hydrochloric acid were to be used as the solvent, and they could not get concordant results, and they thought that on aluminum goods, by their way, no trouble was had in getting everything into solution. Perhaps Mr. Williams will answer that question.

Mr. WILLIAMS. I found that with hydrochloric acid as a solvent complete solution was made. I also found that in two samples sent out this year the reporter said "use A_5." I found that hydrochloric acid alone effected a complete solution, but that if you made duplicate weighings and added to each of those 30 cc hydrochloric acid, boiled them forty minutes, and then added 30 cc nitric acid and continued the boiling, the difference obtained by those two methods would be something like 3 per cent.

Mr. H. K. MILLER. I think there is a weak point just here in our methods. It is quite well understood that different fertilizing materials require different solvents. As methods are now we have the option of applying any of these methods of solution to a fertilizer. I think the matter should be thoroughly investigated, and an indication made as to which method of solution should be applied to the kind of fertilizers we are dealing with. Now recently, at the North Carolina Experiment Station, as Mr. Williams stated, there were quite a number of phosphates that came in, which, when treated by the regular method that was in common use there—that is, the nitric and hydrochloric acid, giving excess to the nitric—were not dissolved, but in the other case practically all the phosphoric acid was obtained. If we are to have these fertilizers of different sources I think we should endeavor to see what form of solvent or what form of solution we should have. I notice in working with this material containing iron and aluminum phosphates that in employing our usual method there—nitric acid with a small quantity of hydrochloric—when incomplete solution was made, there was a blue cast to the solution when diluted, but if hydrochloric was used alone, or with only a small quantity of nitric acid, a colorless solution was obtained. I think the matter should be investigated, and different kinds of fertilizers should have different kinds of solvents.

Mr. JENKINS. It seems to me that in matters of sampling fertilizers and getting your original solution, while specific directions are very helpful to all of us, they can not take the place of individual judgment. Whatever the method—however thoroughly it has been worked out—this method of solution, when you strike a new kind of phosphatic matter—those methods ought not by anyone to be depended on as final and as giving a correct result. It seems to me when a man makes a solution of a fertilizer he is familiar with, he is bound to satisfy himself that it is dissolved, and he can not be certain about it until he has demonstrated to his own satisfaction that the method he uses will give the solution. Nothing can take the place of individual judgment and great care in using the method. I would never undertake to examine a class of phosphatic materials with which I was not absolutely familiar in everyday work, without testing my residues before going further, to see whether the method I was using was absolutely certain to give me a perfect solution. Now, if hydrochloric acid acting on phosphate needs more time let it have it; but you have got to use individual judgment.

Mr. Kilgore. In the line of what Dr. Jenkins says, and in reply to the gentleman inquiring about the methods, I would say that this subject has been very thoroughly investigated by this association. A number of years ago the question of solvents for different fertilizing materials came up. Some of us will remember away back about six years ago when aluminum phosphate in a pure or apparently pure form, containing 40 or 45 per cent, was sent out, and it was difficult to get a solution of this material. Now, when we used nitric and hydrochloric we could not get it. The aluminum phosphate referred to by Mr. Williams, of the North Carolina Station—you can always tell when the material is present in a fertilizer in any quantity by the color of the solution. It does not go into solution readily, and the residue when shaken up gives you that rather pink cast. You can always tell when it is present by that means.

Mr. Wiley. There is a gentleman here, Mr. J. A. Pitcher, representing the State Board of Trade, who would like to extend an invitation to this association.

Mr. Pitcher. Representing the State Board of Trade, which maintains in San Francisco a permanent exhibit of the products of California, I take the liberty, on behalf of the board, to extend you a cordial invitation to view the exhibit. If you could come in a body some afternoon and spend an hour with us, I believe you would agree with us that we have one of the attractions of the city. You would be interested in seeing our samples of what California produces, and in our mining bureau you can find samples of all the minerals in the United States. You will be very welcome, indeed, at any time.

On motion, the invitation was accepted with thanks.

Mr. Wiley. Again I would like to interrupt the regular order, for this reason, that we have had no committee on hour of meeting, because our meetings are a little irregular; but I want to make the statement that for to-morrow afternoon the association has accepted an invitation to attend a reception at the hotel, and I have no doubt that our members who are also members of the other association would like to attend. I therefore propose that we set 10 o'clock to-morrow morning for the meeting, and I make the motion that when we adjourn it be to meet at that time in this room.

The motion was agreed to.

Mr. Hartwell read the following paper:

REPORT ON SOILS AND ASH.

By Burt L. Hartwell, *Referee.*

Contrary to the expressed idea of this association that a referee should hold his position for at least two years, my predecessor, through some misunderstanding, was relieved of his responsibilities in this connection at the end of a single year. As associate referee, the writer was appointed to attend to the duties of referee at least a year earlier than was expected or desirable.

It being already too late to obtain soil from our colder climates, it was deemed advisable, under the circumstances, to secure additonal data concerning some of the soils having the most definite history, which had been worked upon, and to introduce fertile soil from California for the sake of comparison with results already secured from more eastern sections.

My associate was unfortunately separated from me by the width of a continent, and it was January before we could by correspondence decide upon the work to be undertaken. The following circular letter was then sent to the experiment station chemists:

Kingston, R. I., *January 23, 1899.*

Dear Sir: The Association of Official Agricultural Chemists recommended that the work on soil for 1899 include (1) a trial of the so-called international method for determining assimilable potash, i. e. using dilute nitric acid as a solvent (fifth-normal acid will be recommended); (2) a further trial of Höllemann's method for the determination of the active lime compounds, i. e., using water saturated with carbonic acid; (3) further tests with alkaline ammonium chlorid as a solvent for potash; a continued use of calcium chlorid in this connection was considered inadvisable. It seems desirable, in addition to the above, to determine the amount of phosphoric acid in the extract obtained by using the dilute nitric acid mentioned above; to test dilute acetic acid as a solvent for active lime compounds, as well as the carbonated water; to try the efficiency of fifth-normal nitric acid in determining assimilable phosphoric acid, alongside of fifth-normal hydrochloric acid which has been adopted provisionally, inasmuch as the nitric acid is to be tested as a solvent for potash; to further investigate the solvent action of citric acid upon potash and phosphoric acid before discarding entirely this solvent which has given satisfactory results in the hands of so many; and to determine total humus by the official method.

In view of the difficulties which have been encountered in determining silica and potash in ashes, a mixture containing a known amount of these ingredients in the form of silicate of potash, and such other elements as are ordinarily present in ashes, will be distributed to chemists participating in the work. By this means correct indications should be secured as to the efficiency of the method in finding the actual amounts of potash and silica present where there is a large amount of other ingredients.

In order to prosecute the various lines of work upon soils, samples of known and different characteristics should be secured. Certain soils are now in readiness for the work, but as it is desirable to obtain the best available ones, your assistance is solicited in obtaining soils answering the following requirements, viz: (1) Deficient in assimilable potash; (2) deficient in assimilable phosphoric acid; (3) deficient in assimilable nitrogen; (4) deficient in "active" carbonate of lime; (5) containing an abundance of one or more of the above ingredients.

Unfertilized soils are the most desirable, but in case of a soil most lacking in one ingredient it would not be debarred from use even though the other essential ingredients had been added.

The degree of exhaustion of the soils must have been established by soil tests, otherwise the value of a given solvent can not be ascertained.

The soil should contain no exceptional ingredients interfering with its productiveness nor be in need of special treatment to insure good crops, other than an application of the particular elements in which it is claimed to be deficient.

If such soils are not available at present, please report them so that they may be in readiness for future work.

It can hardly be expected that any chemist will be able to undertake all the work outlined, but that certain phases of it will appeal with special interest to different ones. The most valuable results are often secured by chemists working with the soils distributed upon problems not outlined by the referee, and it is hoped that papers embodying such results may be presented at the next meeting.

Your cooperation is earnestly desired. Please state definitely at your earliest convenience what portion of the work you will try to undertake that suitable samples and directions may be sent you. Suggestions from you will be highly appreciated concerning the problems in hand.

Very respectfully,

BURT L. HARTWELL, *Referee.*
M. E. JAFFA, *Associate.*

DIRECTIONS FOR WORK ON ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS' SOIL SAMPLES FOR 1899.

(1) DETERMINATION OF MOISTURE.

Use the official method described in Bulletin 46, page 38, Division of Chemistry, U. S. Department of Agriculture.

(2) DETERMINATION OF PHOSPHORIC ACID SOLUBLE IN FIFTH NORMAL HYDROCHLORIC ACID.

(*a*) *Preliminary treatment.*—Digest 20 grams of soil with 200 cc of fifth-normal HCl in a water bath at 40° for five hours, shaking every half hour. Titrate 20 cc of the clear filtrate against a standard potassium hydroxid solution, using phenolphthalein for the indicator. From the data thus secured calculate the amount of HCl necessary to be added, so that the solution will be fifth-normal after allowing for the acid neutralized.

(*b*) *The determination.*—2,000 to 3,000 cc of acid, corrected for neutralization, as directed under (*a*), are heated in a stoppered receptacle to 40°. Ten grams of soil for every 100 cc of acid are now added and the digestion continued at this temperature for five hours, shaking thoroughly every half hour. The contents are then shaken and filtered through a dry, ribbed filter of two thicknesses of paper and of sufficient size to receive the entire contents, refiltering the first portion of the filtrate if cloudy. A definite volume, comprising nearly all the filtrate, is taken at the temperature at which the original acid was measured, and evaporated to dryness after adding 1 to 3 cc of nitric acid. If there is an appreciable amount of organic matter present ignite the residue carefully, digest with HCl and water, filter, neutralize with ammonia, and 5 cc strong nitric acid and 15 grams of ammonium nitrate. Complete the determination according to one of the official methods.

(3) DETERMINATION OF PHOSPHORIC ACID AND POTASH SOLUBLE IN FIFTH-NORMAL NITRIC ACID.

Proceed with the preliminary treatment similarly as under 2 (*a*), and with the digestion and filtration as under 2 (*b*). Take two definite portions of the filtrate. Use one portion for determining phosphoric acid similarly as in section 2. Evaporate the other portion to a small volume in a porcelain dish, transfer to a platinum dish, add a little sulphuric acid and determine the potash by the Lindo-Gladding method.

In the case of the deficient soils, Nos. 1 and 2, nearly all the filtrate should be used for the single determination.

(4) DETERMINATION OF LIME SOLUBLE IN DECINORMAL ACETIC ACID.

Proceed with the preliminary treatment similarly as under 2 (*a*), and with the digestion and filtration as under 2 (*b*), using from 100 to 200 grams of soil, according to the apparent amount of calcium carbonate present. Evaporate a definite volume comprising nearly all the filtrate, after adding a little HCl to a small volume in a porcelain dish, transfer to a platinum dish, ignite, dissolve in HCl and water, filter, continue with the determination of calcium and the necessary previous separations according to the ash and soil methods, Bulletin 46, pages 40 and 44, Division of Chemistry, U. S. Department of Agriculture. (In the case of soil No. 3 the preliminary treatment will not be necessary; a little manganese will probably be dissolved both by this solvent and the carbonated water.)

(5) DETERMINATION OF LIME SOLUBLE IN CARBONATED WATER.

To from 100 to 200 grams of soil, according to the apparent amount of calcium carbonate present, add for every gram of soil taken, 10 cc of water saturated with pure carbon dioxid. The receptacle in which the digestion is carried out should be provided with a rubber stopper containing two holes sufficiently large to admit easily two glass tubes, each of which shall be closed at the lower end and have a perforation blown in it about 1 inch from that end.

After supplying the acid and soil, adjust the tubes as illustrated, open the pinch cock C, replace the air above the liquid by allowing a current of carbon dioxid to pass through until the escaping gas can be entirely absorbed by caustic alkali. Raise the tubes until the perforations are closed by the stopper, shake vigorously for half a minute, push in the tubes again, and equalize the pressure by allowing carbon dioxid to pass in through A or out through B acccording to circumstances, taking care that no air is admitted, as this would decrease the amount of carbon dioxid in the solvent. Repeat the shaking and venting, as above, nine times at about equal intervals during the working day. At the end of three days filter as usual. Take a definite volume, including nearly all the filtrate, add hydrocholric acid, evaporate to dryness, ignite if necessary, dissolve in hydrochloric acid and water, filter, and determine calcium as in section 5. Verify the saturation of the carbon dioxid water before using by adding to a definite volume an excess of baryta or lime water of known strength and determining that excess by titrating a portion of the clear solution against standard acid. (See Sutton's Volumetric Analysis 7th ed., p. 96.)

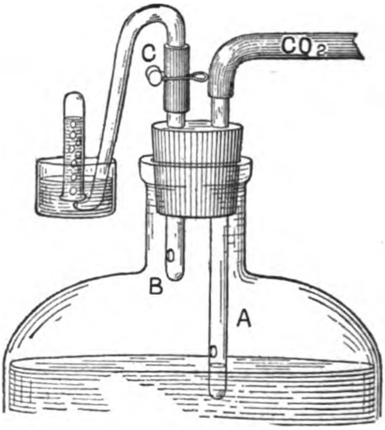

FIG. 1. Apparatus for determination of lime soluble in carbonated water.

(6) DETERMINATION OF HUMUS.

Pass a portion of the soil through a 5-mm. sieve, pulverizing if necessary, and determine the humus by the official method, Bulletin 46, page 42. In the case of difficulty in filtering the ammoniacal solution, a large Buchner filter, under pressure, has been successfully employed.

(7) DETERMINATION OF POTASH SOLUBLE IN AMMONIUM CHLORID.

Make up a twentieth-normal solution of ammonium hydrate by titrating against standard acid, using cochineal as an indicator, and dissolve 17.2 grams of c. p. crystalline ammonium chlorid in each liter of the same. Digest the soil with this solvent and filter as under 2 (*b*). Evaporate a definite portion of the fitrate to a small volume in a porcelain dish, transfer to a platinum dish, and determine the potash by the Lindo-Gladding method.

(8) DETERMINATION OF PHOSPHORIC ACID AND POTASH SOLUBLE IN CITRIC ACID.

Chemists wishing to test the solvent action of citric acid should use fifth-normal acid, following the same general directions for preliminary treatment, digestion, and filtration as given under section 2. The citric acid solution should be used soon after making, as it is liable to ferment. The method outlined in Bulletin 49, pages 81 and 82, of the Division of Chemistry, may be followed for the subsequent treatment.

Blank tests must be made in the potash determination at least, using the same amounts of solvent and reagents as employed when the soil is taken, and the average results repòrted. Report results as soon as the work is completed; it should not be later than June 15, as the association may meet early in July. Calculate the percentages on a water-free basis to the fourth decimal place. The individual determinations rather than the averages should be furnished, after deducting the appropriate blanks.

DESCRIPTION OF SOILS AND DETERMINATIONS TO BE MADE.

No. 1. From Junction City, Ky.—This is the same soil as distributed by the referee for last year as No. 1. It is deficient in available phosphoric acid. The determination of phosphoric acid soluble in fifth-normal nitric acid is desired for comparing with the results secured last year with fifth-normal hydrochloric acid. Three results were reported last year on the amount of phosphoric acid dissolved from this soil by 1 per cent citric acid at room temperature.

No. 2. From the Kentucky Agricultural Experiment Station.—This is the same as distributed by the referee for last year as No. 2. It is deficient in available potash. The determination of potash soluble in fifth-normal nitric acid is desired. A few widely varying determinations of the amount of potash dissolved by ammonium chlorid were reported last year. Additional determinations, using larger amounts of soil and the stronger ammonium chlorid recommended this year at the suggestion of Mr. Huston, who first used it, are solicited from chemists wishing to work with this solvent.

No. 3. From the Rhode Island Experiment Station.—This soil is deficient in available lime, and gives an acid reaction to litmus paper. Determinations of humus and of lime soluble in acetic acid and carbonated water are desired.

No. 4. From Ventura, Cal.—A good representative of the arid upland or bench soils.

No. 5. From Arlington Heights, Southern California.—A soil similar in texture to the eastern loams. Nos. 4 and 5 are abundantly supplied with plant food, and it should be noted in this connection that they contain from 1 to 1.5 per cent of lime. The determinations outlined in sections 3, 4, and 5 are particularly needed for comparison with the soils deficient in plant food. Determine humus in No. 4. The dissolving action of fifth-normal hydrochloric acid, which was adopted provisionally as a solvent for available phosphoric acid, could be well studied upon these soils. The soils are also adapted for further work with citric acid and ammonium chlorid upon fertile soils by chemists wishing to furnish results with these solvents for comparison with what have already been obtained by their use upon other samples.

Nos. 1 and 3 are to be forwarded by A. M. Peter, Lexington, Ky.; Nos. 4 and 5 by M. E. Jaffa, Berkeley, Cal., and No. 3 by Burt L. Hartwell, Kingston, R. I.

BURT L. HARTWELL, *Referee.*
M. E. JAFFA, *Associate.*

KINGSTON, R. I., *March 20, 1899.*

There was so little demand for the ash sample that it was decided to confine the work to the soil samples. Thirteen chemists expressed a willingness to undertake, to a greater or less extent, the soil analysis, and in March the directions for this work were furnished. The chemists were urged to report their results by June 15, in view of the possible early meeting of the association in July. Considerable difficulty was encountered in securing the distribution of certain of the soils, and only a portion of the samples were placed in the hands of the chemists at the time they received the directions.

So few results had been received at the time of writing this report that it was considered wise to request the cooperating chemists to finish the work as soon as time permits, with an idea of embodying it in the report of the referee for the coming year, and to defer until then the publication of the directions which were distributed.

In accordance with the suggestion of our secretary and my own inclinations, an attempt has been made to take a comprehensive glance at the work of the past few years, especially as the results in connection with the present year's work will not be considered at this time.

In 1895 A. M. Peter, the referee for that year, inaugurated a line of work upon soils new to the association. It consisted of a trial of dilute solutions of salts, acids, or their combination, as to their ability to indicate the relative amounts of the more active forms of plant food within the soil in a more satisfactory manner than the stronger solvents previously employed. Since that time various solvents have been recommended for trial by the succeeding referees. In order to discuss intelligently the action of a given solvent upon different soils it becomes necessary to have at hand all the available data possible concerning not only their chemical composition but their geological formation, physical characteristics, crop-producing power, and history. Some of the referees have included in their reports apparently all the facts which were obtainable at the time bearing upon the results. Others, however, have included only very meager descriptions of the soils used. It is very important, in view of the short tenure of office, that each referee include in his report all information which may in the future be of service when the work of a series of years is viewed in its entirety, and which will enable succeeding referees to trace the connection between one year's work and another.

The writer has attempted to compile in a concise form the average results which have been secured on some of the soils with more or less complete records, and upon which considerable work has been done, especially where it has been possible to supplement by new data those heretofore published in the proceedings. These abstracts, as far as the chemical work is concerned, should be compared with the more complete reports containing individual determinations, if one wishes to study closely the records, but it is hoped they will bring the detached results into such form that they will present a more organized appearance, and prove of assistance to anyone taking up this line of investigation.

Unless otherwise stated, the percentages represent the average results secured by a number of chemists, coöperating under the direction of the referee.

SOIL FROM THE EXPERIMENT STATION FARM AT LEXINGTON, KY.

Derived from Lower Silurian limestone, rich in phosphoric acid. Top soil a brown clayey loam; subsoil a yellow clay, so retentive as to cause the land to be deficient in natural drainage; surface soil 8 to 12 inches deep, but the samples were taken 6 inches deep. Cultivated for many years previous to 1888, probably without addition of stable manure or other fertilizer.

In 1888 an experiment was begun with maize, which should indicate the relative amounts of available nitrogen, phosphoric acid, and potash within the soil. Acid phosphate, muriate of potash, and nitrate of soda in amounts furnishing about 57 pounds of available phosphoric acid, 80 pounds of potash, and 26 pounds of nitrogen, respectively, were used per acre each year.

Yields of ear corn per acre, in bushels.

(Acre plots.)

No. of plot.	Fertilizers supplied.	1888.	1889.	1890.	1891.	1892.	1894.	1895.	1896	[1] 1897.
2	None	27	31	40	44	38	13	29	20	10
3	N, P_2O_5, K_2O	63	84	72	56	61	35	57	58	40
4	P_2O_5, K_2O	70	81	65	51	51	30	46	42	32
5	N, P_2O_5	29	35	33	43	29	15	36	24	16
6	K_2O, N	60	87	76	60	62	35	55	42	44
7	None	32	34	34	39	27	15	33	20	14
8	K_2O	....	79	67	54	52	30	45	42	33
9	P_2O_5	....	33	36	38	25	13	30	21	14
10	N	....	41	35	40	27	18	36	28	17

[1] The last year of the experiment. The records for 1893 were destroyed by fire.

Mechanical analysis of the soil from plots 5 and 6.

[1895 Proceedings.]

Made under the direction of Milton Whitney, who remarks: "It has the same texture as our corn and wheat lands, being, in fact, rather light for profitable wheat production."

	Per cent.		Per cent.
Moisture in air-dried sample	2.24	Fine sand, 0.25–0.1 mm	1.26
Organic matter	6.60	Very fine sand, 0.1–0.05 mm	5.28
Gravel, 2–1 mm	1.96	Silt, 0.05–0.01 mm	45.63
Coarse sand, 1–0.5 mm	3.40	Fine silt, 0.01–0.005 mm	13.54
Medium sand, 0.5–0.25 mm	2.69	Clay, 0.005–0.0001 mm	17.67

Chemical analysis of air-dried fine soil from an unfertilized plot.

[1894 Proceedings, A. O. A. C.—Provisional method.]

	Per cent.		Per cent.
Insoluble matter	80.520	P_2O_5	.418
K_2O	.422	N	.190
CaO	.379	Moisture	1.941
MgO	.381	Ash from humus	2.170
Fe_2O_3	3.251	P_2O_5 in humus ash	.170
Al_2O_3	6.191		

4.33 per cent of the original soil failed to pass the 0.5 mm. sieve. This iron gravel or "shot iron ore" contained 2.117 per cent P_2O_5, and if it had been included with the fine soil would have materially increased the Fe_2O_3 and P_2O_5. The latter, in a soil passing 1 mm. sieve, would have been increased to 0.502 per cent.

By digesting 10 grams of the fine soil in 100 cc normal oxalic acid six hours at 100°, J. H. Kastle and others removed as much P_2O_5 and about half as much K_2O as by the provisional method.

K_2O and P_2O_5 dissolved in digestion of fine soil (calculated to water-free basis).

[Soils from experiment-station farm, Lexington, Ky.]

Plot.	Solvent.	Cubic centimeters solvent to 1 gram soil.	Time of digestion.	Temperature of digestion.	Per cent of P_2O_5.	Per cent of K_2O.
	Frequent shaking by hand.					
2[1]	N/5 hydrochloric acid	100	5 hours	40° C.	....	0.012
2	N/5 calcium chlorid	100	5 hours	40° C.	....	.005
2	N/5 citric acid	100	5 hours	40° C.	....	.007
2	Ammonium citrate (fert. sol., 1 in 10)	100	5 hours	40° C.	....	.007
2	N/5 oxalic acid	100	5 hours	40° C.	....	.009
2	Ammonium oxalate (16 grams per liter)	100	5 hours	40° C.	....	.012
7[2]	N/5 calcium chlorid	100	5 hours	40° C.	....	.006
7	Ammonium chlorid (10.68 grams per liter) of N/20 NH_4HO.	100	5 hours	40° C.	....	.0104
5[3]	Citric acid (10 grams per liter)	50	5 hours	Room	0.0268	.0039
6[3]	.....do	50	5 hours	Room	.0235	.0050
5	Ammonium oxalate 40 grams, acetic acid 2.15 grams, per liter.	50	5 hours	Room	.0733	.0060
6	.....do	50	5 hours	Room	.0661	.0113

[1] Proceedings A. O. A. C., 1896.

[2] Proceedings A. O. A. C., 1898; samp. taken Mar., 1898.

[3] Proceedings A. O. A. C., 1895; samp. taken Nov., 1894.

K_2O and P_2O_5 dissolved in digestion of fine soil (calculated to water-free basis)—Continued.

[Soils from experiment-station farm, Lexington, Ky.]

Plot.	Solvent.	Cubic centimeters solvent to 1 gram soil.	Time of digestion.	Temperature of digestion.	Per cent of P_2O_5.	Per cent of K_2O.
	Frequent shaking by hand.					
5	Oxalic acid (6.3 grams per liter)	50	5 hours	Room	.0562	.0060
6	.....do	50	5 hours	Room	.0575	.0074
5	Oxalic acid (1 per cent sol.)	50	5 hours	Room	.1100	....
6	.....do	50	5 hours	Room	10.40	....
5	Oxalic acid (equivalent to 1 per cent citric)	50	2 hours	Room	.1135	.0040
6	.....do	50	2 hours	Room	.1062	.0067
5	Acid potassium oxalate (equivalent to 1 per cent citric).	50	2 hours.	Room	.1067	....
6	.....do	50	2 hours.	Room	.0976	....
5	Acetic acid (equivalent to 1 per cent citric)	50	2 hours.	Room	.0014	.0013
6	.....do	50	2 hours.	Room	.0017	.0043
5	Citric acid (10 grams per liter)	50	7 days	Room	.0560	.0038
6	.....do	50	7 days	Room	.0511	.0069
5	Total by hydrofluoric acid	....	....	....	....	1.105
6	.....do	....	....	....	....	1.147
	Constant shaking by machine.					
5[1]	Ammonium oxalate 40 grams, acetic acid 2.15 grams, per liter.	50	5 hours.	Room	.0776	.0183
6[1]	.....do	50	5 hours.	Room	.0625	.0189
5	Ammonium oxalate 40 grams, ammonia equivalent to 2.15 grams acetic acid, per liter.	50	5 hours.	Room	.0165	.0144
6	.....do	50	5 hours.	Room	.0138	.0226
5	Ammonium chlorid 17.2 grams, ammonia equivalent to 2.15 grams acetic acid, per liter.	50	5 hours.	Room	.0	.0134
6	.....do	50	5 hours.	Room	.0	.0176
5	Ammonium chlorid 17.2 grams per liter	50	5 hours.	Room	.0	.0218
6	.....do	50	5 hours.	Room	.0	.0238
5	Ammonium chlorid 17.2 grams, ammonia 0.96 specific gravity 1 liter.	50	5 hours.	Room	.0	.0137
6	.....do	50	5 hours.	Room	.0	.0162
5	Ammonia 0.96 specific gravity	50	5 hours.	Room	.0352	.0148
6	.....do	50	5 hours.	Room	.0337	.0140
5	Ammonium oxalate, 40 grams, acetic acid, 2.15 grams per liter.	50	5 hours.	65° C.	.0565	.0200
6	.....do	50	5 hours.	65° C.	.0492	.0185
5	Ammonia oxalate, 40 grams, ammonia, equivalent to 2.15 grams acetic acid per liter.	50	5 hours.	65° C.	.0195	.0135
6	.....do	50	5 hours.	65° C.	.0222	.0175
5	Ammonium chlorid, 17.2 grams, ammonia, equivalent to 2.15 grains acetic acid, per liter.	50	5 hours.	65° C.	.0	.0165
6	.....do.	50	5 hours.	65° C.	.0	.0196
5	Total by J. L. Smith method	....	....	....	....	1.467
6	.....do	....	....	....	....	1.465

[1] Proceedings A. O. A. C., 1896.

SOILS FROM THE EXPERIMENT STATION FARM AT KINGSTON, R. I.

The soil here mentioned is from the "plain." It is of a dark chocolate color, about 4 inches deep, underlaid by an impure clay resting upon gravel and pebbles of unknown depth, which form a good natural drainage. The soil is evidently derived from gneiss, consisting of quartz, orthoclase, and biotite, and made up of glacial drift.

Mechanical analysis.

(1895 Proceedings.)

Made under the direction of Milton Whitney, who remarks that it has "the same texture as our early truck soils."

	Per cent.		Per cent.
Moisture in air-dried sample	1.90	Fine sand, 0.25–0.1 mm	6.66
Organic matter	8.46	Very fine sand, 0.1–0.05 mm	31.65
Gravel, 2–1 mm	1.82	Silt, 0.05–0.01 mm	29.69
Coarse sand, 1–0.5 mm	3.40	Fine silt, 0.01–0.005 mm	4.38
Medium sand, 0.5–0.25 mm	7.82	Clay, 0.005–0.0001 mm	4.81

Chemical analysis of air-dried fine soil.

(Bulletin 28, Rhode Island Experiment Station. Collected 1892. Hilgard method.)

	Per cent.		Per cent.
Insoluble matter	80.632	P_2O_5	0.127
K_2O	.155	Moisture and organic matter	7.888
CaO	.569	Humus	2.752
MgO	.209	Ash from humus	.605
Fe_2O_3	3.463	P_2O_0 in humous ash	.042
Al_2O_3	4.641		

It was found (1895 proceedings) that the amount of P_2O_5 extracted from these soils, rich in organic matter, was increased 41 per cent by substituting the Goss for the above method.

Soil taken from different portions of the same field in 1895 contained, on a water-free basis, humus, 3.86 per cent (by the Huston method, which gives higher results than the Hilgard method, in most cases); humous nitrogen, 0.13 per cent; and free humic acid,[1] 1.52 per cent (Rhode Island station). Soil which had been exhausted of its available potash by fertilization with N and P_2O_5, taken from the same field in 1897, yielded only 0.020 per cent of lime by treatment with carbonated water (1898 proceedings). The soils under discussion give an acid reaction to litmus paper and fail to produce satisfactory yields in the case of many crops, without an addition of lime or other alkaline materials to correct the existing acidity.

In 1890 an experiment was begun with maize to indicate the relative amounts of more active nitrogen, phosphoric acid, and potash within the soil. Previous to this time grass had been growing for many years without fertilization, and hardly enough was produced at the time the experiment began to pay for cutting. In 1890 and 1891 nitrate of soda, 150 pounds; dissolved boneblack, 350 pounds, and muriate of potash, 150 pounds, per acre were applied. In 1892 and subsequently the annual application was increased to 480, 600, and 200 pounds, respectively. In 1896 air-slacked lime was applied to all plots at the rate of 2½ tons per acre.

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[1] Method given in Wiley's Agricultural Analysis, vol. 1, p. 331.

Yields of maize (ears and stover) in pounds.

No.	Fertilizers supplied.	Before liming.					After liming.		
		1890.	1891.	1892.	1893.	1894.	1896.	1897.	1898.
1	N	180	60	60	50	26	10.6	103.3	215
2	P_2O_5	210	129	130	145	88	20.8	32.6	130
3	K_2O	293.8	107.5	61	112.5	28	11.9	133.8	295
4	N, P_2O_5	273.8	139.5	205	122.5	116	38.5	180.3	350
5	N, K_2O	282.5	112.5	88	102.5	32	26.8	222.5	395
6	K_2O, P_2O_5	293.8	157.8	230	163.8	202	49.2	230.8	335

NOTE.—In 1894, 1896, and 1897 other crops were also planted, and the above yields for those years were from a few rows only of maize. The yields during the other years are those from one-twentieth acre plots. No maize was planted in 1895. The experiment is still being continued.

K_2O and P_2O dissolved in digestion of fine soil calculated to water-free basis.

[Soils from Experiment Station farm, Kingston, R. I.]

Plot.	Solvent.	Cubic centimeters solvent to 1 gram soil.	Time of digestion.	Temperature of digestion.	Per cent of P_2O_5.	Per cent of K_2O.
	Frequent shaking by hand.					
5[1]	Citric acid (10 grams per liter)	50	5 hours	Room	0.0178	0.0122
2	.....do	50	5 hours	Room	.0175	.0037
5	Ammonium oxalate, 40 grams, acetic acid, 2.15 grams, per liter.	50	5 hours	Room	.0331	.0142
2	.....do	50	5 hours	Room	.0286	.0054
5	Oxalic acid (6.3 grams per liter)	50	5 hours	Room	.0153	.0158
2	.....do	50	5 hours	Room	.0180	.0077
5	Oxalic acid (1 per cent solvent)	50	5 hours	Room	.0280	....
2	.....do	50	5 hours	Room	.0250	....
5	Oxalic acid (equivalent to 1 per cent citric)	50	2 hours	Room	.0319	.0117
2	.....do	50	2 hours	Room	.0356	.0029
5	Acid potassium oxalate (equivalent to 1 per cent citric).	50	2 hours	Room	.0133	....
2	.....do	50	2 hours	Room	.0189	....
5	Acetic acid (equivalent to 1 per cent citric)	50	2 hours	Room	.0004	.0097
2	.....do	50	2 hours	Room	.0009	.0018
5	Total, by hydrofluoric acid	....	....	....	....	1.542
2	.....do	....	....	....	....	1.659

[1] Proceedings A. O. A. C., 1895.

SOIL FROM THE FARM OF G. F. DOLE, SHELBURNE, MASS.

A good medium loam of glacial origin, a mica-schist till. Had been in grass without manure for five years previous to the following experiment.

The field upon which the experiment to determine available plant food was conducted was upon an elevated tract in a hilly district. One hundred and sixty pounds of nitrate of soda, 320 pounds of dissolved boneblack, and 160 pounds of muriate of potash were annually applied per acre.

Yields per twentieth-acre plot, in pounds.

No. of plot.	Fertilizers supplied.	1889, maize.		1890, maize.		1891, potatoes.		1892, oats.		1893, hay.	1894, hay.[1]
		Ears.	Stover.	Ears.	Stover.	Large.	Small.	Grain.	Straw.		
1 4 8	Av. None	121	124	82	105	27	35	21	32	49¼	57¾
2	N	136	162	90¾	107¼	22	35	24	38½	99	95½
3	P_2O_5	153	148	107¾	94¼	91	50	30	35	65	62
5	K_2O	163	161	93¾	136¼	75	38	26	51½	48½	57
6	N, P_2O_5	172	168	114½	135½	200	51	32	70½	211¾	138¾
7	N, K_2O	185	196	96	129	123	42	37	58	137	98½
9	K_2O, P_2O_5	157	178	108¾	121¼	84	29	21	34	57	75
10	N, P_2O_5, K_2O	175	216	105	122	113	49	39½	65½	158¾	110

[1] The results for 1895, the last year of the experiment, are not included, for there was evidence of the crops from the different plots having been mixed by the person in charge.

Chemical analysis of air-dried fine soil.

[Furnished by W. P. Brooks, Amherst, Mass. Sample collected in 1889.]

	Per cent.		Per cent.
Insoluble matter	80.93	N	0.18
K_2O	.15	Moisture	2.17
P_2O_5	.13	Organic matter	8.41
CaO	.16		

Goss and Hare obtained 0.22 per cent P_2O_5 by the Goss method from soil collected from the same area in 1895.

P_2O_5 dissolved in digestion of fine soil (calculated to water-free basis).

[Soil from farm of G. F. Dole, Shelburn, Mass. Sample was probably collected in 1895 from an unfertilized plot. Frequent shaking by hand. (Proceedings A. O. A. C., 1896.)]

Solvent.	Cubic centimeters solvent to 1 gram.	Time of digestion.	Temperature of digestion.	Per cent of P_2O_5.
N/5 hydrochloric acid	100	5 hours.	40° C.	0.019
N/5 citric acid	100	5 hours.	40° C.	.033
Ammonium citrate (fert. solution dilute 1 in 10)	100	5 hours.	40° C.	.021
N/5 oxalic acid	100	5 hours.	40° C.	.091
Ammonium oxalate (16 grams per liter)	100	5 hours.	40° C.	.011

In answer to inquiries for more definite information concerning soil sample No. 3, distributed by the last referee, with a view to using it in the work of the present year, the agriculturist of the North Carolina Experiment Station writes in part as follows: "The land was apparently a fair representative lot of much of the neighborhood, which generally needs complete manure and organic matter for the production of profitable crops. The cotton, as judged by the stalks left on the ground and the number of empty bolls left, could not be otherwise than deficient in at least one of the essentials of plant food, and we believe in more, or all." This information throws more light upon the character of the sample in question, and emphasizes the difficulty expressed by the referee of last year in obtaining soil of known deficiency for testing the value of a solvent.

Considerable data upon the relative solvent power of dilute acids for phosphoric acid and potash having been secured from time to time upon soils from different localities, they are compiled in the following tables as a more convenient form of reference:

Amount of phosphoric acid dissolved (calculated to percentages of water-free soil).

	Kentucky.		Rhode Island.		Massachusetts.	New Mexico.	Rothamsted, England.	
	Plot 5.	Plot 6.	Plot 5.	Plot 2.			Plot W. 3.	Plot B_2 A.
Proceedings	1895.	1895.	1895.	1895.	1896.	1896.	1897.	1897.
Time of digestion	2 hours.	2 hours.	2 hours.	2 hours.	5 hours.	5 hours.	5 hours.	5 hours.
Temperature of digestion	Room.	Room.	Room.	Room.	40° C.	40° C.	40° C.	40° C.
Strength of acids	n/7.	n/7.	n/7.	n/7.	n/5.	n/5.	n/5.	n/5.
Oxalic acid	0.1135	0.1062	0.0319	0.0856	0.091	0.083	....	....
Citric acid	.0169	.0154	.0107	.0125	.033	.025	....	....
Acetic acid	.0014	.0017	.0004	.0009	....	....	....	....
Hydrochloric acid	....	....	....	....	.019	.049	0.0039	0.0357
Nitric acid	....	....	....	....	....	....	.003	.029

Amount of potash dissolved (calculated to percentages of water-free soil).

	Kentucky.			Rhode Island.		Rothamsted, England.	
	Plot 2.	Plot 5.	Plot 6.	Plot 5.	Plot 2.	Plot W. 3.	Plot B_2 A.
Proceedings	1896.	1895.	1895.	1895.	1895.	1897.	1897.
Time of digestion	5 hours.	2 hours.	2 hours.	2 hours.	2 hours.	5 hours.	5 hours.
Temperature of digestion	40° C.	Room.	Room.	Room.	Room.	40° C.	40° C.
Strength of acids	n/5.	n/7.	n/7.	n/7.	n/7.	n/5.	n/5.
Oxalic acid	0.009	0.0040	0.0087	0.0117	0.0029	....	....
Citric acid	.007	.0040	.0073	.0111	.0021	....	....
Acetic acid	....	.0013	.0043	.0097	.0018	....	....
Hydrochloric acid	.012	....	....	....	....	0.019	0.016
Nitric acid	....	....	....	....	....	.019	.017

It may be noticed that oxalic, citric, and acetic acids decrease in the order named in their ability to extract both phosphoric acid and potash from the soils considered. Hydrochloric acid dissolves more potash from the Kentucky soil than oxalic and citric acids, and from the Rothamsted soil about the same as nitric acid; in regard to phosphoric acid, it extracts more than nitric acid from the Rothamsted soil, but its position in relation to oxalic and citric acids is uncertain, as shown by the Massachusetts and New Mexico soils. The results show how the relative dissolving power of two acids may vary upon soils of different nature, depending possibly upon the combinations in which the ingredient in question occurs.

In considerable of the work done by the association in determining the more active constituents of plant food, the results secured upon a soil which had received no application of a given substance are compared with those upon the same soil to which had been added, in the course of plot experimentation, a known amount of the ingredient in question in an available form. The value of a given solvent has been judged according to its ability to extract a larger amount of a given ingredient from the soil receiving an application of the same than from the one to which it has not been added. Had there been no loss by drainage the differences in the total amounts, at least of a constituent found by analysis, should be accounted for by the net amounts added to or removed from the different plots. In the case of the Kentucky soils (1895 Proceedings) which were deficient in natural drainage, and therefore less liable to loss from leaching, the increase of potash in plot 6 over plot 5 as a result of the system of fertilization during the preceding seven years amounted to 431 pounds per acre, or 0.0431 per cent, using 1,000,000 pounds as the approximate weight of the soil per acre at the depth sampled, 6 inches. It is interesting to compare this percentage with the difference between the percentages of potash found in the soil from plots 5 and 6, as shown below:

	Plot 5.	Plot 6.	Difference.
Goss method (H_2SO_4 and HNO_3)	0.486	0.540	0.054
Official method (HCl 1.115 sp. gr.)	.315	.330	.015
Hydrofluoric acid	1.105	1.147	.042
J. Lawrence Smith method[1]	1.467	1.485	.018

[1] Huston and Bartlett, 1896 Proceedings.

In like manner the increase of phosphoric acid in plot 5 over plot 6 amounts to 486 pounds per acre, or 0.0486 per cent.

	Plot 6.	Plot 5.	Difference.
Goss method	0.450	0.462	0.012
Official method	.430	4.31	.001

It was possible with the data at hand to calculate only approximately the net increase of potash in plot 5 over plot 2 in the Rhode Island soils (1895 Proceedings) during the four years preceding the collection of samples. It would amount to about 460 pounds per 1,000,000 pounds of soil, or 0.0460 per cent.

	Plot 2.	Plot 5.	Difference.
Goss method	0.305	0.287	−0.018
Official method	.152	.156	.004
Hydrofluoric acid	1.659	1.542	− .117
J. Lawrence Smith method	1.549	1.486	− .063

Upon the same basis the increase of phosphoric acid in plot 2 over plot 5 would be 380 pounds, or 0.038 per cent.

	Plot 5.	Plot 2.	Difference.
Goss method	0.251	0.262	0.011
Official method	.191	.202	.011

At the Indiana Experiment Station (Huston and Bartlett, 1896 Proceedings), soil was examined from plots which had been in an experiment five years. Accepting arbitrarily, in the absence of other figures, 1,000,000 pounds as the weight of this soil per acre, at the depth sampled, it appears from the published information that the increased percentage of phosphoric acid, in the plot receiving a complete fertilizer over the blank plots, calculated from the fertilizers applied and crops removed, would be 0.0069 per cent, while the difference in analysis by the official method was —0.005

per cent. The increase in phosphoric acid in the plot receiving barnyard manure over the blank plots appears by a similar calculation to be 0.0119 per cent, and by analysis, —0.016 per cent. The excess of potash in the plot receiving complete fertilizer over the blank plots would, by calculation, be 0.0075 per cent, but according to analysis is 0.021 per cent (official method) and —0.081 per cent (J. L. Smith method). The excess of potash in the plot receiving barnyard manure over the blank plots would by calculation be 0.0176 per cent, but according to analysis is 0.022 per cent (official method) and 0.078 per cent (J. L. Smith method).

It will have been noticed from the foregoing that whereas in a large majority of cases an increased application of an element of plant food to one plot over another has been indicated to some extent by the analysis, in many instances the analytical results are the opposite of what we would expect from the history of the plots. It may be well to state in this connection that, with the exception of those upon the Indiana soil, all results by the official and Goss methods are averages of determinations by a number of chemists; the remaining results represent, as a rule, the work of one person in each case.

It would seem reasonable to expect that the total amount of an ingredient found by analysis would, in the case of the various plots, indicate the ones which had received an addition of that ingredient, even if no correspondence existed with the amounts added during a series of years. On the contrary, the analytical results are very conflicting, showing, in the case of total potash by the Smith method, for example, in two out of the four instances, a considerably larger amount of potash in the soil which had been to some extent exhausted of its supply, than upon that which had received potash for a series of years, and in the other two instances they fail to show the differences which would have been anticipated from the amount of potash applied. Of course, it should not be expected that the analytical results would coincide with the history of the plots, but unless our strong solvents indicate with more certainty than they have in the instances cited the additions of plant food, are we in a position to expect an agreement even in direction, if not in degree, between the amounts dissolved by weak solvents and the records of the soils? As a rule, even our strong solvents previously considered find only a small fraction of the net amount of plant food applied in soluble forms during several years. Conceding the accuracy of our results, it becomes a very interesting problem from an agricultural standpoint to account for this loss.

In studying the results of the past few years, it is apparent that much good work has been done, and that the agreement in the results by different chemists improves. It must be borne in mind, however, that determinations embodying 100 or more grams of soil must be scrutinized to the third decimal place with the same attention that we would give the tenths of per cent in considering the results from a determination embodying 1 gram of material, and that the percentage difference should always be considered in comparing the results from different chemists. The blank obtained by digesting, in a glass receptacle, an amount of solvent equal to that used in connection with the soil, may, in the cases of potash determinations at least, amount to a large percentage of the weight obtained, and should, of course, never be omitted in work of this nature. It is hardly safe for the referee to take it for granted that all necessary precautions will be taken by every cooperating chemist, and he must emphasize them, even at the risk of being considered paternal. In view of the difficulty of obtaining exhausted soils in which the deficient element is positively known, and of subsequently securing a sample of the same which shall truly represent the area under consideration, it would seem advisable to procure, in advance, soil which probably would prove deficient in some essential constituent and, by means of a plot experiment with a portion of the same, settle any doubt as to its deficiency in the particular ingredient. If the soil proves suitable for the work, samples can then be distributed to the chemists, and the results compared with the crop records upon the identical lot of soil. By this method any material, the lack of which might be suspected of being the cause of unproductiveness, instead of the one supposed to be deficient, can be supplied. The experience at the Rhode Island Station with the soil used in the work of this association in 1895, which showed a lack of phosphoric acid before liming, but not afterwards (see article by Wheeler, 1898 Proceedings, p. 60), emphasizes the liability of being misled by many of the soil tests as at present conducted.

Our success in drawing right conclusions in regard to the value of a solvent must depend in a very large degree upon our correct knowledge of the productiveness of the soil, and our carefulness in obtaining representative samples. The writer is forced to the conclusion that with proper attention to these particulars we shall have fewer inexplainable results. We shall very likely be unable to find any one solvent which shall predict the amount of active plant food in soils of very differing characteristics, and, of course, the capabilities of a soil for the production of one crop would be very different for another.

At first thought it was supposed that the relative action of the different solvents employed during the past few years could be explained upon the ground that the principal form in which the ingredients existed in one soil was very different from its combination in another. This difference has undoubtedly been very marked in certain of these soils, but the data at hand seemed insufficient to substantiate deductions upon this point, especially as results by different chemists were sometimes in conflict. It would be highly desirable if there could be published, in connection with the results with the weak solvents, determinations by some experienced chemist, which would throw light upon the peculiar combinations in which the ingredient exists. It must be evident in the case of soils like the ones examined by Ladd, of the North Dakota Experiment Station, for example, in which over half of the phosphoric acid resisted the action of weak hydrochloric acid, though subsequently dissolved with the humus by ammonia, that a dilute acid solvent would fail to indicate the assimilable phosphoric acid with the same completeness as upon a soil containing its active phosphoric acid in forms readily attacked by acids. Evidence is accumulating that there are many soils in which the phosphoric acid is largely associated with the humus, and in a form quite readily available to plants.

In view of the fact that large amounts of soil should be taken when a weak solvent is employed in order to get a fair weight of precipitate, a coarser sieve than the 0.5 mm. size should be adopted for this line of work. After corresponding with a number of chemists in regard to the best size, I recommend the adoption of a 3 mm. sieve, where the soil is to be used for determinations requiring 100 grams or more. This is the size employed quite generally by European workers and its use would be an advantage in comparing results. It would, except in rare cases, include all soil particles which would be appreciably attacked by the solvents in question.

The CHAIRMAN. Are there any papers to be presented on this subject, or is there any discussion to be had on this paper?

Mr. GOSS. I do not know that I quite followed the referee in regard to these figures on the paper at the front. After a large amount of experimenting I gave up the idea entirely of being able to determine the difference between the several soils—that is, in the amount of available plant food present, by using strong solvents. I do not think it can be done. I think, however, that the strong solvent should be used in the analysis of a soil as a means of determining or attempting to determine the total stock of plant food available that may be drawn upon. Now in regard to difference in results secured by action of the acids that has been mentioned, it has been my experience that this is due often—in most cases—to the presence of lime and magnesia in the soil, which has a neutralizing action. There are a great many soils that will completely neutralize fifth-normal acid. Of course the solvent effect would not be comparable in that case with soils having little carbonate of lime. So this must be taken into consideration in discussing the solvent effect of weak acid.

Mr. WILEY. The point brought out by the referee in the discussion of these data, in which it was shown that, calculating from the amount of material added to the soil, some of these conditions were in the wrong direction, is an extremely important one. It seems to me that that one fact alone should incite the members of this association to enter into a more careful and intimate examination of some of the problems underlying soil analysis. Now everyone will admit that the knowledge of the soil is the fundamental knowledge necessary to scientific agriculture. You may throw the climate in sometimes, but the soil remains stationary, and it is the fundamental environment in which the crops must be grown, not to be changed very much in position or very much in quality. And yet we find that in some cases our methods of analysis seem to point to incorrect results. I think some of the suggestions made will explain the problem. The differences in making a test are very great, for instance, whether we should use a sieve of larger dimensions. It seems to me that it is practically impossible in the methods which we have at hand to make a uniform mixture of these soils. So it seems to me that some of the samples may have been taken which never received any fertilizer at all, and that therefore this would be the explanation. It is a mechanical matter. I would not as the result of this most interesting study throw any imputation upon the skill of the analyst nor upon the method of analysis, but it seems to me, as the referee suggested, that it may be wholly in the method of sampling, and I am inclined to believe that when these discrepancies have been thoroughly investigated it will be found chiefly in just this direction.

Mr. FREAR. It seems to me that I can rely on what the secretary has said, that we need to study more carefully the differences in these samples. Several years ago in studying variations in composition of barnyard manure—another substance difficult to sample—I found great difficulty in securing material which I considered as fairly representative. In order to check the matter I took seven series of samples, each one of which would be supposed to be perfectly representative material, but yet I found quite marked differences, making triplicate determinations so as to be sure of my own results. And so I believe that in these closer studies of the soil we will find it necessary to check up our sampling before we too closely criticise results. I think it would be desirable before too severely criticising, or before accepting any man's analysis based upon certain analytical samples, to check up the samples which have been the basis of our determination. I should prefer to examine two or three samples of the same soil.

Mr. **Hartwell.** I am glad to have this brought out. I know that in the case of certain of these soils the samples were taken from as few as six places on a 20-acre lot, and in more recent work the soil has been taken from a less number of places than that, and I think the referees must be doubly careful about this matter before requiring a large amount of work by the chemists throughout the country.

A **Member.** Were there any results on ash?

Mr. **Hartwell.** The reporter has had only one or two requests for the samples, and it seemed hardly worth while to send them out. There has been no work done in this direction.

Mr. **Kilgore.** Mr. President, it seems to me that the interest in the analyses of plants—ash analyses—is becoming pretty general, and we have not gotten very much work in this direction. for the last three years. The work on soil has rather monopolized the time of referees and workers, and the idea was suggested by Mr. Hartwell, and I was in hopes he would bring it out, that perhaps it might be a good idea to separate these two subjects and have a reporter on ash in addition to the regular reporter on soils. It would appear that there is enough work there for a referee on each subject. This idea was suggested by the referee himself, and I hoped he would bring it out. I move, Mr. President, that we refer this matter, with the recommendation, to the committee on recommendations, to report back to the association whether they consider it advisable or not to have an additional referee on this subject.

Mr. **Hartwell.** In regard to the matter of dividing this work, as the last speaker said, we have had very little results from ash work in the last two years; and in fact for a number of years back the same may be true. This, I think, has been largely because the ash has been considered a separate or side issue, and sometimes has been loaded onto the associate referee; and the simple sending around of a number of samples seems to be more a test of chemists than of method and has not yielded us valuable results. To my mind there is no doubt that there should be considerable work done on our methods of ash analysis, and it would well occupy the attention of a separate referee. The determinations of the soil work and the ash work are very numerous, whereas we have in the case of potash and nitrogen a referee devoted to a single determination. I feel that our methods for ash analysis may lead to incorrect results in this particular, whereas, starting with samples of ash where different results may be had, I think the greater difficulty lies back of that, in starting with the dry material. This is especially true where large amounts of silica and potash are present. Of course our methods emphasize the fact that particular care must be taken in such cases, but in my own work upon ash rich in silica I have been unable to get parallel results, starting with the dry material. Probably it is practically impossible to get all the adherent sand away from the surface of a sample of material, and failing in that we depend upon the determination of insoluble silica to furnish the amount of pure ash in the sample.

In this same connection I would like to call attention to the work of Shuttleworth, who has recently completed his doctor's degree in Germany, and published a monograph on this question which is very interesting. I think this matter could well demand the attention of a separate referee. Especially, as the stations progress in their work, and field experiments are carried on, it will be absolutely necessary to make more determinations of the ash in the future.

The CHAIRMAN. You have heard the question of the advisability of dividing the subject of soil and ash analyses. What is your pleasure?

It was moved that the division be made. Carried.

The CHAIRMAN. We will now take up the subject of foods and feeding, by Thorn Smith.

Mr. WILEY. The referee is not present, nor is his associate. Both have sent interesting reports, but I would like before reading them to suggest that there has been such a short time since the last meeting that we have not as much before us so we usually have, and it is quite likely that we shall finish in the morning session. For that reason I would like to state that a very important subject will be brought up—a report of the committee on food standards, which seems to me of more interest than any other now before us. This will be presented to-morrow morning, and I hope all who can will be here and enter into the discussion of this highly important subject. I may say that one of the chief reasons for the interest in the matter just now is the fact that the United States Congress, as will be brought out in the report, has recognized the authority of this association already on the subject of food commerce, as the committees in the House and Senate have both reported bills as to interstate commerce in adulterated foods, recognizing this association as the authority for fixing the matter of adulterated foods. It is, therefore, quite certain that in a short period this association will be recognized as the authority in all matters relating to the adulteration of foods, the use of preservatives, and everything of that kind. So I say this is a matter of great importance and should be discussed before a full house. It will come at the end, being put down as the last thing to be done.

I might remind the president that it is his function to say when the report of the committee on nominations shall come in; but this report of which I have spoken will come in immediately before the business of the association is finished. We shall have an hour's business before that comes up, so that it will not come up, probably, before 11 o'clock.

Mr. Thorn Smith, of Moscow, Idaho, writes that he sends his report, saying that it is the best he can do at present.

REPORT ON FOODS AND FEEDING STUFFS.

By THORN SMITH, *Referee.*

It is difficult to understand why such an apathy exists in regard to the perfection of methods for the estimation of the various carbohydrate bodies. Is it because so little is known in regard to this work and our chemists hesitate in taking up something comparatively new, or is it because the perfecting of a method which will obtain results varying but the few hundredths of a per cent by different analysts in regard to phosphoric acid or potash is more important? Is not a comprehensive knowledge of what we eat and feed our domestic animals of more importance than a few hundredths of a per cent of potash? Are we, who have made such rapid strides in analytical methods, to let our foreign friends take this, our grandest opportunity, from us?

In the past few years that the association has devoted itself to this problem of differentiating the nitrogen-free extract, the work has been left in the hands of the few. Widely discordant results have been the reward and a certain amount of depreciation is shown these pioneers. Year after year a few of the faithful have taken up the work, published their results, and gone at the problem with renewed vigor the following year, while their brother chemists let it go by difference and call that difference nitrogen-free extract. How many stations in the country are not called upon in the course of a year for an analysis of something containing these elements reported as nitrogen-free extract, and assigned a feeding value known to be false? Is it not about time that more of us grappled with these problems? If we are to continue our present system of perfecting methods why not have the active cooperation of thirty or more stations instead of the four or five that we now have? It would not take long at this rate to see daylight.

Your referees, not being able to secure the results on the samples sent out this season in time for this meeting, have acted on the suggestion of our honorable secretary and propose to give a very brief outline of the work done by the association on the subject of foods and feeding stuffs as related to the estimation of the starch, pentoses, and galactose. Mr. Browne has prepared a special paper on the subject of starch.

The first suggestion made during a meeting of the association that we should differentiate in what is called the nitrogen-free extract was made, I believe, in 1890. Some work of an individual nature had been attempted in several institutions, but not as a part of the association's work. Clifford Richardson attempted some work in 1883, but abandoned it as unprofitable and not worth the time, considering the labor involved and the lack of suitable methods. It was Mr. Frear who in 1889 said, "I shall be very much disappointed if within the next four or five years a point has not been reached where, instead of being content with the present grouping, we shall in studies of digestibility and nutritive value be satisfied with nothing less than a complete investigation of the foods used." That time has come and gone, twice over, and we are just now making a beginning. In 1890 a committee consisting of some of the most prominent chemists in the association made a lengthy report. W. E. Stone at the same time presented a valuable paper on the estimation of pentosans in feeding stuffs. At this time it appeared as though something were going to be done, but the subject was not mentioned in the next three meetings, except in 1893, when it was suggested by the referees that the subject be taken up. In 1894, however, Mr. Patterson attacked the matter in a vigorous manner, and the work promised much. Only three reported on the subject of nitrogen-free extract; however, the ball was rolling. At the same meeting Mr. Stone and Mr. Krug presented results of valuable study. And yet we had not even a provisional method for this work, not even for starch. The discussion developed nothing, for the subject was not even mentioned. This was truly discouraging to the referees. In 1895 Mr. Patterson continued his labors without success, so far as arousing any discussion was concerned. Was this due to lack of interest or to ignorance of the subject? At this time, however, the referees were successful in having some methods incorporated in the "official methods of analysis."

In 1896 a wise move was made in dropping out of the referee work all other than the differentiation of the nitrogen-free extract. The standing of Mr. Lindsey, the referee, gave prestige to this departure, and, as he said, "These terms do not refer to a single substance, but rather to groups of substances possessing similar charcteristics." And Mr. Lindsey was right. There can be no permanent value in a method which aims to determine several constituents at one time, and if our work accomplishes anything these methods will become obsolete in a few years at the most. Under the vigorous administration of Mr. Lindsey the work so ably started by Mr. Patterson was prosecuted with renewed vigor. At this time also a little interest was manifested in the work. In 1897 Mr. Lindsey again gave valuable assistance in furthering this work. A few points were brought out in the discussion, and yet but few appeared interested. In 1898 the work was taken up by Mr. Krug. He had given considerable attention to it for several years and was ably prepared to carry it along. He was able from the results obtained to recommend material changes and also to propose interesting lines of investigation for future referees. The association has been exceedingly fortunate in having such able and strong men to guide this departure in its initial stages, and it is to be sincerely hoped that the referees of the future will do all in their power to carry on the work so nobly begun.

Gentlemen, I beseech you to give all the aid that you possibly can. Let us demonstrate our ability to cope with this, the most difficult problem that now confronts us. I have told you in as few words as possible, that you may not be wearied, of what the association has done, and I hope that a little more interest may be aroused. Our results lack much to make them satisfactory, and it is only by hard work that we can hope to make them otherwise. Let us wake up to our possibilities and perfect these methods which so perplex us.

In the work outlined for the present year we have made no radical changes. The suggestions of Mr. Krug, last year's referee, have been incorporated in our scheme of analysis, and believing that much of the variation is due to inexperience and manipulation, it can only be a question of time and application before better results are obtained. Seventeen stations are cooperating with us, and we look for good results. While we are unable to make a report at this time, we shall endeavor to report fully at a later date.

Moscow, Idaho, *June 26, 1899.*

Mr. Wiley (continuing). Then comes the report of the associate referee:

THE ESTIMATION OF STARCH.

By C. A. Browne, Jr., *Associate Referee on Foods and Feeding Stuffs, 1899.*

Of all the various methods employed for the estimation of starch, the diastase method stands to-day as the one most universally approved by chemists. In testing the superiority of this over other methods of analysis the Association of Official Agricultural Chemists can pride itself upon having taken a most prominent part. Perhaps no other line of work better illustrates the advantages to be derived from such cooperative researches as the association is undertaking from year to year. We think it fitting, therefore, in this connection to give a brief history of the progress made along this particular subject since the organization of the association.

The analysis of fertilizers occupied the whole attention of the association during the first two years of its existence; the subject of fodders and feeds was not referred to committees until 1886, but for several years nothing was done toward the investigation of those bodies which are still classified as nitrogen-free extract, the attention of the reporters being principally directed to the perfection of methods for determining crude fiber, ether extract, albuminoids, moisture, and ash.

In his address before the association at the Chicago meeting in 1893, the president, S. M. Babcock, suggested a closer study of the different constituents of feeds and advised "substituting for the present illogical, indefinite, and unmeaning system, one which, so far as it went, would deal with the proximate constituents which the fodders contain." A very general demand was made by members of the association for investigation along the lines suggested by President Babcock, and through the energies of the referee on feeds for the following year, H. J. Patterson, the work was given a vigorous start.

Conspicuous among the papers presented at the 1894 meeting is one by W. E. Stone upon "A comparison of methods for the determination of starch." Five of the commonly employed methods were tested and compared upon a large variety of materials. Outside of the samples of pure starch a considerable discrepancy is noted in the results obtained by these methods. Stone shows that this error is due to the presence of other bodies, such as pentosans, which behave toward acids in much the same way as starch, and draws the unavoidable conclusion that none of the existing methods, based upon the conversion of starch to dextrose by direct inversion, can be employed with any degree of accuracy upon materials containing pentosans. The use of diastase, which had begun to meet with favor among European stations, is suggested as one way of meeting this difficulty. We believe that the use of diastase in starch analysis was brought to the attention of the association for the first time on this occasion. The original diastase method of Stone was included among the methods to be tested the following year, but was not reported upon by any of the chemists.

The work marked out by Mr. Patterson was continued for the year 1896 by J. B. Lindsey. Three distinct methods for the estimation of starch were proposed—the Sachsse, the Märcker, and the diastase, the latter method appearing in a form slightly modified from the original. The results of the various analysts demonstrated the inaccuracy of the Sachsse method; the Märcker and diastase methods agreed fairly well, and were adopted by the association as provisional methods until further investigation could be made. In his work the following year Mr. Lindsey dropped the Sachsse method and substituted the salicylic-acid or modified Bundy method for trial instead. A larger number than usual of chemists participated in the work, the general results of the investigation establishing the superiority of the diastase over all other existing methods. The association accordingly adopted the diastase as the provisional method for the determination of starch in all substances except commercial starch and potatoes.

H. W. Wiley and W. H. Krug presented two very important papers on the subject of starch analysis before the Association of American Chemists at the Detroit meeting in 1897. A serious error, due to unconverted starch, was pointed out in the ordinary method of conducting the digestion with diastase, and the importance of testing the residues with iodine under the microscope was shown. The authors also felt "justified in announcing that diastase has no solvent action on the pentosans, and is a reliable means for determining the exact starch content of a cereal or fodder."

The referee for the year 1898, W. H. Krug, limited the work on starch solely to the diastase method. Results were obtained from thirteen chemists. The analyses revealed considerable variation, the probable causes of which are discussed by Mr. Krug to some extent. Differences in the amount of moisture in the different samples, incomplete solution of the starch by diastase, and variations in the time of treatment with the malt solution are all considered as possible sources of discrepancy.

The only important change adopted at the 1898 meeting was in regard to making the iodine test for unconverted starch with the microscope. It is evident that while the process as it stands is the best method which we have at our disposal for estimating starch, there is still need of further improvement at certain points before uniform results can be secured by different chemists.

Mr. WILEY (continuing). Before taking up this subject for discussion, or adjourning, I will say that I have only two more reports, which can be disposed of in an hour, and I think these are the only ones to be taken up. The other referees have not come in person or sent their reports by mail. If we begin by 10 o'clock, I think we can finish our session to-morrow.

Mr. Goss read the following paper:

CONCERNING THE 6.25 PROTEIN FACTOR AS APPLIED TO BEEF.

By ARTHUR GOSS.

In connection with the nutrition investigation work carried out in the New Mexico Experiment Station in 1897, and reported in Bulletin No. 54 of the United States Department of Agriculture, Office of Experiment Stations, the following investigation concerning the 6.25 protein factor was undertaken.

For this work a 2½-year-old range steer, of as nearly as possible average condition, was selected. After butchering one side was cut into fifteen different pieces, as outlined in Armour & Co.'s diagram, which is given below:

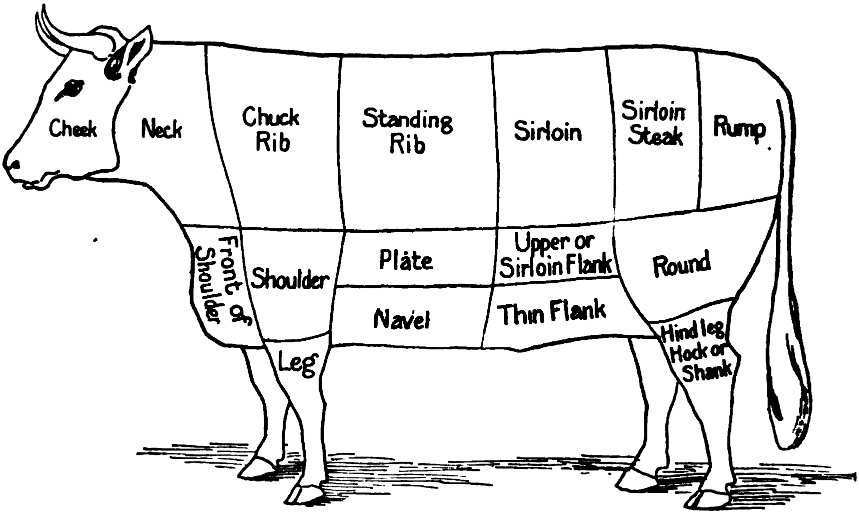

FIG. 2.—Diagram showing cuts of beef used in this investigation.

Each cut was then carefully weighed, the meat separated from the bone, and the amount of each determined. The edible portion of each cut was chopped into very small pieces, the entire lot carefully mixed, and a small sample separated by quartering. The small sample was then run through a sausage mill two or three times, well mixed, and a 200-gram sample weighed into a tared saucer and dried below 100° for two or three days. After drying the sample was allowed to stand in free contact with the air for about forty-eight hours, to assume as nearly as possible a state of moisture equilibrium. After again weighing, and thus determining the per cent of water lost in air drying, the partly dried sample was ground up in an iron mortar as finely as possible and passed through a sieve. Most of the samples were sifted through a half-millimeter sieve, but a few, like the leg, containing much tendon and similar tissue, could not be gotten through so fine a sieve, one or two of the most difficult requiring a 2-millimeter sieve. After grinding and sifting the samples were bottled for analysis.

The substances usually determined in the analysis of meat for the purpose of determining its value as food are water, ash, fat, and protein. In case the water, ash, and fat are determined, the protein is usually taken by difference—that is, the sum of the water, ash, and fat is deducted from 100, and the result called protein. In case it is desired to determine the protein alone, it is usually done by determining the percentage of nitrogen in the sample and multiplying the same by 6.25.

While this 6.25 factor is doubtless practically correct for some proteids, it has been shown repeatedly that these substances differ in their percentage of nitrogen, and that theoretically it would be necessary to use a different factor for each. In the case of an ordinary sample of meat there are always several proteids present, so that in practical work the best that can be done is to secure a factor which shall be as nearly as possible an average for the entire lot.

It was thought worth while in connection with the analysis of the side of beef described above to determine exactly what factor should be used for each particular cut. This side of beef was particularly adapted to this investigation, as the samples contained a very small percentage of fat, and the extremely dry New Mexico climate permitted of drying the analytical samples until little water remained, thus reducing the errors incident to the fat and moisture determinations to the minimum.

In the determination of moisture it was found necessary to dry the samples in a current of dry hydrogen at the temperature of boiling water for about five hours in order to secure practically constant weight.

In the determination of ash the samples were burned in platinum dishes for from three to five hours at a temperature just below redness, the burning in all cases being continued until the ash was perfectly white.

The essentials of successful ash work in the case of meat samples are a good furnace, with the heat under perfect control, and plenty of time. It should not be attempted to hasten the operation by using too high a temperature, as in that case loss is liable to occur from volatilization, and, furthermore, the fusible salts melt and form a coating around the unburned carbon, thus excluding the oxygen necessary for combustion and making it next to impossible to secure a white ash.

The fat was determined by extracting the water-free material in a Soxhlet's extractor with anhydrous ether until all the material soluble in that reagent was removed.

In order to determine the time necessary to accomplish this end, before beginning on the regular samples from the side a series of determinations were run with some samples of round and sirloin steak.

As a result it was found to be necessary to extract longer than twenty-four hours. In all the subsequent work the extraction was continued for forty-eight hours, it being assumed that practically all the soluble material was removed in that length of time.

The results of the above investigation are given in Table 1.

TABLE 1.—*Concerning length of time necessary to extract with ether in the fat determination.*

No. of sample.	Name of cut.	Fat removed first twenty-four hours.	Fat removed second twenty-four hours.	Total fat removed in forty-eight hours.
547	Round steak (animal No. 1):	*Per cent.*	*Per cent.*	*Per cent.*
	a	7.87	0.21	8.08
	b	7.91	.17	8.08
	Average	7.89	.19	8.08
546	Sirloin steak (animal No. 8):			
	a	1.41	.22	1.63
	b	1.55	.22	1.77
	Average	1.48	.22	1.70
548	Sirloin steak (animal No. 1):			
	a	7.91	.15	8.06
	b	7.55	.23	7.78
	Average	7.73	.19	7.92
	Average of averages	5.70	.20	5.90

The fat, so called, even in the case of meat, is never absolutely pure. Probably the principal impurity in the case of meat samples is nitrogenous material, which is either carried down mechanically with the fat or is soluble in ether. In the case of a number of the above samples the ether extract, after being dried and weighed, was dissolved out of the fat flask, transferred into a Kjeldahl digestion flask, and the nitrogen determined in the usual manner. The average of these results, as will be seen by referring to Table 3, was 0.03 per cent of nitrogen, which is equivalent to 0.19 per cent of protein, provided the 6.25 factor is used in calculating. This amount should be deducted from the per cent of ether extract and added to the per cent of protein as determined by difference.

The nitrogen was determined by the Kjeldahl method, 1 gram usually being taken for analysis.

The utmost care was taken in this investigation to secure reliable analytical results. All samples were analyzed in duplicate, and sometimes three or four and even as many as sixteen determinations were made on the same sample. While the duplicate results might have been closer in some cases, provided the samples could have been ground to pass a finer sieve, it is believed that the averages are not very far from correct.

In the nitrogen work all the measuring vessels used were carefully calibrated and the correction factors introduced. It was found in the calibration work that considerably more reliable results could be secured in measuring by the use of pipettes than by means of burettes. An automatic pipette was consequently made and attached to the standard acid bottle, and the acid used measured out in this way. In calibrating this pipette, which held 23.12 cc, a difference of but 0.02 cc was found between the highest and lowest of the four consecutive readings taken.

The next step in the work was a thorough checking up of all the reagents used in the determination. The standard half-normal hydrochloric acid used was prepared by titrating against chemically pure sodium carbonate which had been dried just below redness for four or five hours to constant weight. As a further check on the strength of the acid chemically pure potassium carbonate, dried to constant weight, was used. Upon introducing the proper corrections for temperature of solutions, calibration of pipettes used, etc., and working with the utmost care, it was very gratifying to find that by using Clarke's latest atomic weights the results were almost absolutely identical with the two carbonates.

As a further check on the work samples of bone meal, cotton-seed meal, tankage, and dried blood were secured from Mr. J. P. Street, A. O. A. C., reporter on nitrogen, and check determinations made. This resulted in the detection of a small error due to impurities in the reagent that might otherwise have escaped notice. It also furnished a rather striking example of the unreliability, in some cases, of agreement between duplicate determinations as a means of avoiding error. Upon running a pair of blank determinations with all the reagents used in the nitrogen determination present, in both cases nitrogen was found to be absent. Upon adding a little sugar, however, and making the determination as before, 0.17 cc of half normal hydrochloric acid was neutralized, and upon repeating the determination with a different amount of sugar and different amounts of salicylic acid present an amount of nitrogen corresponding to the above amount of half-normal acid was actually proven to be present in the reagents. The nitrogen was probably present as a nitrate, and had escaped reduction in the absence of organic matter in the first determinations.

In order to determine the length of time necessary to digest the samples with sulphuric acid and mercuric oxid portions of sample No. 548 were digested for one-half, one, two, three, and four hours, respectively. The results secured are given in Table 2.

TABLE 2.—*Showing length of time necessary to boil with sulphuric acid and mercuric oxid in the nitrogen determination.*

Quantity of meat employed.	Sulphuric acid.	Mercuric oxid.	Length of digestion.	Nitrogen.
Grams.	*cc.*	*Grams.*	*Hours.*	*Per cent.*
1	30	0.7	1-2	(a) 13.50
1	30	.7	1-2	(b) 13.50
1	30	.7	1-2	av. 13.50
1	30	.7	1	(a) 13.55
1	30	.7	1	(b) 13.59
1	30	.7	1	av. 13.57
1	30	.7	2	(a) 13.66
1	30	.7	2	(b) 13.55
1	30	.7	2	av. 13.61
1	30	.7	3	(a) 13.68
1	30	.7	3	(b) 13.66
1	30	.7	3	av. 13.67
1	30	.7	4	(a) 13.68
1	30	.7	4	(b) 13.62
1	30	.7	4	av. 13.65
2	30	.7	1	(a) 13.55
2	30	.7	1	(b) 13.47
2	30	.7	1	av. 13.51

The results given above in Table 2 would seem to indicate, as Atwater and Woods have already pointed out,[1] that it is necessary to digest meat samples somewhat longer than ordinary vegetable substances. This work would seem to indicate that three hours' boiling was sufficient in the case of meat samples, but to be safe the boiling was continued in each case in the actual determinations for four hours.

After getting the nitrogen machine in good working order the nitrogen was determined in each sample, and the protein calculated by using the 6.25 factor. The protein was then compared with that found by differences, and the proper factor for the cut calculated.

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[1] U. S. Dept. of Agr., Office of Experiment Stations Bull. 44, p. 25.

In Table 3 is given the correct factor for each cut and the data from which the same was figured. In calculating the protein by difference, the average amount of protein found in the ether extract was deducted from the fat and added to the protein in each case.

TABLE 3.—*Composition and correct protein factor for each cut.*

No.	Name of cut.	Water-free substance.				Edible portion.			
		Ash.	Ether extract.	Nitrogen in ether extract.	Fat. (Protein ether extract deducted.)	Nitrogen.	Protein. N×6.25.	Protein, by difference.	Correct factor for cut.
		Per ct.	*Per ct.*	*Per ct.*	*Per cent.*	*Per ct.*	*Per ct.*	*Per cent.*	
554	Neck	4.7	2.7		2.5	15.31	95.7	92.8	6.06
555	Chuck rib	4.7	5.6		5.4	14.70	91.9	89.9	6.12
556	Standing rib	4.7	4.7		4.5	14.81	92.6	90.8	6.13
557	Sirloin	4.9	3.6	0.05	3.4	14.69	91.9	91.7	6.24
558	Sirloin steak	4.9	3.6	.03	3.4	14.83	92.7	91.7	6.18
559	Rump	5.0	2.6	.03	2.4	15.12	94.5	92.6	6.12
560	Round steak	5.1	4.0	.03	3.8	14.69	91.8	91.1	6.20
561	Hock, hind leg, or shank	4.6	5.9	.04	5.7	14.77	92.3	89.7	6.07
562	Upper or sirloin flank	4.6	2.6	.03	2.4	15.14	94.6	93.0	6.14
563	Lower or thin flank	4.3	3.4	.03	3.2	15.38	96.1	92.5	6.01
564	Plate	4.7	2.1	.03	1.9	15.51	96.9	93.4	6.02
565	Navel	4.4	2.0	.03	1.8	15.65	97.8	93.8	5.99
566	Shoulder	4.9	6.4		6.2	14.55	90.9	88.9	6.11
567	Leg	4.3	6.1		5.9	14.85	92.8	89.8	6.04
568	Front of shoulder	4.9	3.7		3.5	14.88	93.0	91.6	6.16
	Average			.03					6.11
	Equivalent to protein (N × 6.25)			.19					

By referring to Table 3 it will be seen that the correct factors for the different cuts varied from 5.99 in the case of the navel to 6.24 in the case of the sirloin. In a general way it would seem that for such cuts as the sirloin, sirloin steak, and round steak, in which the greater part of the sample is pure muscular tissue, the 6.25 factor is more nearly correct than in the case of such cuts as the navel, lower or thin flank, and leg, in which tendon and connective tissue is present in comparatively larger quantity. This point is brought out in a more striking manner in Table 4, in which the factors for the different cuts have been arranged in order of size. It will be noted that 6.25 is too high in each case.

TABLE 4.—*Correct protein factors for the different cuts, arranged in order of size.*

No.	Name of cut.	Factor.	No.	Name of cut.	Factor.
565	Navel	5 99	559	Rump	6 12
563	Lower or thin flank	6.01	556	Standing rib	6.13
564	Plate	6.02	562	Upper or sirloin flank	6.14
567	Leg	6.04	568	Front of shoulder	6.16
554	Neck	6 06	558	Sirloin steak	6.18
561	Hock, hind leg, or shank	6.07	560	Round steak	6.20
566	Shoulder	6 11	557	Sirloin	6.24
555	Chuck rib	6 12			

TABLE 5.—*Showing correct protein factor for entire side.*

Edible portion.—Water-free substance.

No.	Name of cut.	Total weight.	Protein (N × 6.25).		Protein by difference[1].	
		Grams.	*Per cent.*	*Grams.*	*Per cent.*	*Grams.*
554	Neck	372	95.7	356.0	92.8	345.2
555	Chuck rib	1,235	91.9	1,135,0	89.9	1,110.3
556	Standing rib	2,311	92.6	2,140.0	90.8	2,098.4
557	Sirloin	1,238	91.9	1,137.7	91.7	1,135.2
558	Sirloin steak	2,098	92.7	1,944.8	91.7	1,923.9
559	Rump	1,270	94.5	1,200.1	92.6	1,176.0
560	Round steak	2,553	91.8	2,343.6	91.1	2,325.8
561	Hock, hind leg, or shank	621	92.3	573.2	89.7	557.0
562	Upper or sirloin flank	427	94.6	403.9	93.0	397.1
563	Lower or thin flank	573	96.1	550.6	92.5	530.0
564	Plate	323	96.9	313.0	93.4	301.7
565	Navel	294	97.8	287.5	93.8	275.8
566	Shoulder	743	90.9	675.4	88.9	660.5
567	Leg	287	92.8	266.3	89.8	257.7
568	Front of shoulder	1,302	93.0	1,210.9	91.6	1,192.6
	Average per cent protein for entire side, by dividing total weight protein in side by total weight dry matter	....	92.91	....	91.31	....
	Average protein factor for entire side.	....	....	....	6.14	....

[1] Corrected for N in ether extract.

In Table 5 is given the data from which the factor for the entire side was figured. It would obviously be incorrect to simply take the average of the factors for the different cuts as the average for the entire side, as the cuts are of different weights. By calculating the amount of protein in each cut as found by difference, and as determined direct by using the 6.25 factor, and dividing the sum of these amounts by the total weight of dry matter in the different cuts, the correct percentage of protein for the whole side can be determined. Then by the proportion—

Per cent of protein by N × 6.25 : per cent of protein by difference :: 6.25 : X

we can determine the correct factor for the entire side. This was found to be 6.14, and if the small amount of carbohydrates said to be present in beef were considered, this factor would become still smaller to a slight extent.

While it is not supposed that this 6.14 factor is correct for all the different proteids, or possibly for any one of them in a pure state, it is thought to be more nearly correct for the average side of beef than is the 6.25 factor used at present.

The proper factor for different animals, or even for the same animal under different conditions, would probably vary somewhat, and it is only by continued work and the accumulation of analytical data that the true relations in such cases will become apparent.

In Table 6 is given the average results of the analyses of three samples of round and sirloin steak from different animals, as purchased in the market. In sampling, as much fat as possible was removed, the object being to secure as nearly pure muscular tissue as possible. Even though as much fat as possible was removed, there still remained considerably more of that substance in some of the samples than was present in the samples from the range animal, showing that the animals from which these samples were taken were in much better condition than the range steer.

TABLE 6.—*Composition and correct protein factors for samples of pure lean round and sirloin steak.*

No.	Name of cut.	Water-free substances.						
		Ash.	Ether extract.	Protein in ether extract N × 6.25	Fat.	Protein by difference.	Protein by direct determination N × 6.25	Correct protein factor for cut.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
547	Round steak as sold in market, animal No. 1	4.6	8.2	0.25	8.0	87.4	88.3	6.19
548	Sirloin steak as sold in market, animal No. 1	4.5	8.1	....	8.0	87.5	87.8	6.23
549	Sirloin steak as sold in market, animal No. 2	4.5	9.8	.06	9.6	85.9	85.6	6.27
	Average	....	....	.16	....	....	....	6.23

By referring to Table 6 it will be seen that the average protein factor for these samples is considerably nearer 6.25 than the average factor for the range animal. Upon comparing the averages for the corresponding cuts, however, it will be seen that there is not very much difference, the average for the corresponding cuts from the steer being 6.19, and for the samples from the shop 6.23.

This would seem to confirm the statement already made that the 6.25 factor is probably more nearly correct for such cuts as round and sirloin steak, in which the greater portion is pure muscular tissue, than for such as the leg and flank, in which there is much tendon and connective tissue. It is not to be overlooked, however, that the comparatively few samples analyzed would not warrant any very definite conclusions in this connection.

It would afford an interesting study to dissect out portions of tendon, pure muscular tissue, etc., and compare the protein factors for each.

Mr. WOODS. In connection with the paper just read, I am afraid we must not pin too much faith to that kind of work unless we go back somewhere else. If we take meat and dry it at the temperature of this room with the air pump you will lose nitrogen. Anywhere from 2 to 15 per cent of the nitrogen in the meat will go off in the air; and you will also find that if you extract meat with ether it will give off ether extract almost indefinitely. You will also find that if you dry two duplicate samples of meat in a stream of hydrogen, and in one case the hydrogen does not pass through the dish, they will not agree. They will be as far as 2 or 3 per cent apart. I have compared 750 of these samples, and I doubt whether we can do very much in just this way. We have got to separate the materials and study them by themselves. We have got to experiment upon an enormous amount of meat before we can learn much about the composition of it. I think in order to study this matter, interesting and painstaking as this work is, and valuable as it would be if we are sure of the facts back of it, we have got to take it with considerable allowance.

Mr. GOSS. If it is true, as Mr. Woods has stated, that nitrogen is lost in drying, then this factor should be even less than 6.15—6.25 is undoubtedly too much.

Adjourned.

THIRD DAY'S PROCEEDINGS.

President Kedzie called the association to order.

The president called for the report on foods and food adulterations, by Prof. H. A. Weber. Professor Weber was not present, and the secretary stated that he had sent no report, and suggested that the discussion of the subject be postponed, to be held in connection with the report of the committee on food standards, which was to come later.

The president then called for the report of the referee on insecticides and fungicides. In the absence of the referee, Dr. de Schweinitz, the associate referee, Mr. L. A. Voorhees, presented a report, which was read by the secretary, as follows:

REPORT ON FUNGICIDES AND INSECTICIDES.

By Louis A. Voorhees, *Associate Referee.*

The Association of Official Agricultural Chemists, until its third annual convention of 1886, confined its efforts and the scope of its work to the analysis of fertilizers. Committees had been appointed and work much needed at that time had been done on the methods of determining phosphoric acid, potash, and nitrogen. At this third convention, however, the importance of the chemical examination of cattle foods and dairy products caused the association to unanimously adopt such changes in its constitution as to permit it to include committees on these and other materials connected with the agricultural industry; and since this time we find the importance of the work causing that on nitrogen to include the determination of nitrates, ammonia salts, and organic nitrogen, and their availability; that on potash to consist of a strict and discriminating examination of the various steps in the methods and variations applicable to the various salts and other substances to be met with; and that on phosphoric acid to comprise many new methods and to embrace the determinations of iron and alumina. The methods for the examination of soils and ash have been assigned to a separate committee, and involve the determination of all the common mineral constituents of plants and soils.

Reporters on tanning materials and on sugar have been established, and work on cattle foods and dairy products has grown to the extent of including a more exhaustive examination of the nitrogen-free extract in the case of the former and a search for adulterations, preservatives, etc., in both cases. This has naturally led to the examination of food intended for man, so that flour, meal, bread, spices, condiments, baking powders, vinegar, etc., have received our attention in response to the demands of our station workers in animal industry and in the nutrition of plants, the lower animals, and man.

In the meantime our coworkers with the microscope, the botanists and entomologists have been making progress, and consequently now make their demands of the analytical chemist. At the time of the third convention referred to (1886) there were barely half a dozen scientific men in the United States working from an economic standpoint on the problem of plant diseases, their injuries, life histories, characteristics, and preventives.

When in 1888 the experiment stations were established in the various States, the subject of plant diseases was at once recognized as one of the important lines of work, it being, in fact, specially mentioned in the organic law upon which they were founded; and in many stations investigators at once began work upon the problems involved. Results of immense practical importance have already been obtained in these investigations and experiments, and it is safe to say that had the experiment stations done nothing more for agriculture than to obtain these and other similar results concerning plant diseases, the money spent upon them by the Government would have been wisely invested.

Likewise, as the experiment stations were organized and the agricultural colleges were enlarged and strengthened by Government assistance, the vital importance of economic entomology to successful agriculture became recognized. The increase in noxious insects from various causes, not the least of which is their enormous power of multiplication, led to a constantly increasing injury to cultivated crops. With this increase, however, our knowledge of controlling them has also been augmented with the passing years. Spraying has become a recognized part of the season's operations, as much so as fertilizing and cultivating, and hence demands and receives very large attention from the workers of the agricultural experiment stations, and worthily, since in many sections the depredations of insects and blight of fungi prevail, whereas the questions of artificial fertilization are there just arising.

With the increase in the use of "chemicals" as fungicides and insecticides, the mycologist and entomologist have become more and more in need of the assistance of the analyst; the temptation to adulterate is greater than when comparatively small amounts of these chemicals were used by the agricultural public; imitations have been devised, and the mixtures and combinations of chemicals have been prepared and put upon the market "ready-made." Recognizing this increasing field of agricultural chemistry, analytical control (particularly of arsenicals) has been established in some States after the manner of the fertilizer control, and at its last meeting this association took the matter under consideration and appointed a referee and associate to study the methods to be employed. It is to be regretted that sufficient time has not been available to give the subject exhaustive treatment, and that this report is, therefore, but introductory.

The principal chemicals and other substances in use by entomologists and mycologists at the present time are contained in the following list, which may, however, be incomplete:

Ammonia (aqua).
Arsenicals.
Calcium oxid (fresh lime).
Carbon disulphid.
Copper carbonate.
Copper sulphate (blue stone).
Lead acetate (sugar of lead).
Mercuric chlorid (corrosive sublimate).
Potassium cyanid.
Potassium sulphid.
Potassium hydoxid (potash lye).
Sodium carbonate.
Sodium hydroxid (soda lye).
Sulphur, flowers of.
Sulphuric acid.
Carbolic acid.
Fish oil.
Formalin.
Kerosene oil and crude petroleum.
Pyrethrum.
Tobacco preparations.
White hellebore.

Of these materials practical experience seems to indicate that ammonia water, fresh lime, carbon disulphid, copper sulphate, lead acetate, mercuric chlorid, potassium sulphide, sodium carbonate and hydroxid, flowers of sulphur, sulphuric acid, carbolic acid, fish oil, kerosene, crude petroleum, pyrethrum, and white hellebore are either sufficiently uniform in quality or are of the strength designated by the manufacturer. On the other hand, copper carbonate could be adulterated. Potassium cyanid ranges from 68 to 98 per cent of purity, which is of importance to the nurseryman in fumigating his houses, not only because the hydrocyanic gas may be diminished in amount, but also because of the injury to his stock from the deleterious gases which may be liberated from the impurities, and 98 per cent pure should always be insisted upon. "Potash lye," in the trade, has been found in many instances to be sodium hydrate, which concerns not the mycologist so much as the entomologist in making up a "whale oil" soft soap. Formalin is supposed to be a 40 per cent solution of formaldehyde in water, but its uniformity has been questioned, since it has sometimes failed to preserve specimens in the laboratory. Tobacco and tobacco preparations depend for their efficiency largely upon the nicotin which they may contain, and there are also various imitations and ready-made preparations (proprietary) on the market which demand analysis.

But the materials which are most in need of examination and control are the arsenicals—Paris green, London purple, and the various substitutes and imitations are extremely variable. In 1897, 11 samples of Paris green were examined by Prof. William S. Myers, of Rutgers College, for the entomologist of this station, and to his report was appended the following comment:[1]

> The above results varying so widely—from 41.54 per cent of arsenious oxide to 68.59 per cent—seemed difficult to understand on first comparisons. According to the last edition of the United States Dispensatory, Paris green is the aceto-arsenite of copper. The theoretical percentage of arsenious oxid in it is 58.65. The Massachusetts Report for 1895 gives the average of a number of samples as 59.94 per cent, and Mr. Cathcart, in the New Jersey Experiment Station Report for 1890, who states that there are two compounds sold under the name of "Paris green"—the arsenite as well as the aceto-arsenite of copper—finds as high as 68.82 per cent of arsenious oxid in a sample. The arsenite of copper, according to Sharples (Chemical News, 35, 88-108), contains only 41.93 per cent of arsenious oxid, but is subject to wide variation in composition and purity, depending upon the degree of concentration of the liquid from which the body is crystallized. With no water of crystallization, the arsenious oxide may run as high in the pure pigment as 52.95 per cent.
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> Bloxam and older authorities have published formulas requiring from 50 per cent to 70 per cent of arsenious oxid. According to Wagner, the other body, the aceto-arsenite of copper, is only an empirical formula, in which the copper may exist as suboxid and the arsenic be present as arsenate. Here is also an opportunity for considerable variation from the theoretical per cent of 58.65. It is not, therefore, surprising to find wide variations in the commercial products, when we have three possible theoretical figures, viz, 41.93 per cent, 52.94 per cent, and 58.65 per cent, and, when actual figures have been obtained, as high as 59.94 per cent and 68.82 per cent. We have no reason to believe, consequently, that the samples were adulterated.

In addition to the Paris green there are found on the market many preparations in imitation of or as substitutes for it. The Maine Experiment Station (Bulletin 52, p. 6) notes the following: "Green arsenite," "Paragrene," "Emerald green," "Arsenite of soda," and "Arsenate of lead." Green arsenite is the plain arsenite of copper, as noted in Professor Myers's comment above, but the New York Experiment Station at Geneva (Bulletin 158, p. 14) notes that "Lead arsenite is also colored and sold under the incorrect name 'green arsenite.'" In addition, "New process Paris green, Lion Brand," and "Laurel green," analyzed at the Kentucky Agricultural Experiment Station (Tenth Annual Report, 1897, pp. xx, xxi), are shown to be mixtures containing little Paris green, if any.

The Adler Color and Chemical Works have recently put upon the market an arsenate of lead, an arsenite of lead (which they call "Pink arsenoid"), an arsenite of copper ("Green arsenoid"), and an arsenite of barium ("White arsenoid").

From all of this it would seem that analytical work on insecticides and fungicides is much needed, and at present should include the following determinations: Copper, cyanogen, alkalies, formalin, nicotin, and arsenic.

On account of the absence of the referee for this subject, and the earliness of the convention of the association, there has been no time for analytical work in these directions, but the following methods are proposed for study and experiment.

A qualitative analysis should precede in most cases, especially in unfamiliar goods, and may for some purposes take the place of the quantitative determination. The regular tests may be used. Wendell Paddock (New York Exp. Sta., Bulletin 121, p. 219) proposes the following quick test, though not infallible, of the purity of paris green:

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[1] N. J. Exp. Sta. Report, 1897, p. 408.

Pure Paris green will readily dissolve in ammonia, and the solution will be of a deep blue color. If there is any residue left, or if the solution does not become blue at once, adulteration may be suspected.

Formaldehyde may be qualitatively detected in an unknown solution by the tests described on page 113 of the proceedings of the convention of this association in 1897 (Bulletin No. 51, Division of Chemistry).

QUANTITATIVE METHODS.

The following quantitative methods are suggested:

Copper.—Determine copper as cuprous sulphid by Rose's method, Fres. Quant. Anal., edition of 1886, page 316. This, slightly modified, is as follows: Precipitate the solution—which is best moderately acid, but should not contain a great excess of nitric acid—according to the quantity of copper present, either by the addition of strong hydrogen sulphid water or by passing the gas. In the absence of nitric acid it is well to heat nearly to boiling while the gas is passing, as this makes the precipitate denser, and it is more easily washed. When the precipitate has fully subsided, and you have made sure that the supernatant fluid is no longer colored or precipitated by strong hydrogen sulphid water, filter quickly, wash the precipitate without intermission with water containing hydrogen sulphid, and dry on the filter with some expedition. Transfer to a weighed porcelain crucible, add the filter-ash and some pure powdered sulphur, and ignite gently while the sulphur vapor is burning quietly around the crack in the cover. As soon as this has ceased heat strongly for five minutes, allow to cool in the stream of hydrogen, and weigh the cuprous sulphid (Cu_2S).

Potassium cyanid.—Determine purity by Liebig's volumetric method. It is based on the fact that when a solution of silver nitrate is added to an alkaline solution containing cyanogen, with constant stirring, no permanent precipitate of silver cyanid occurs until all the cyanogen has combined with the alkali and the silver to form a soluble double salt (in the presence of potash, for example, KCy, AgCy). If the slightest excess of silver over and above the quantity required to form this combination be added, a permanent precipitate of silver cyanid occurs, the double compound being destroyed. If, therefore, the silver solution be of known strength, the quantity of cyanogen present is easily found; 1 eq. of silver in this case being equal to 2 eq. cyanogen.

"So fast is this double combination that when sodic chlorid is present no permanent precipitate of silver chloride occurs until the quantity of silver necessary to form the compound is slightly overstepped." (Sutton's Volumetric Analysis, edition of 1890, p. 173, which see for further details, and also Fresenius Quant. Anal., edition of 1886, p. 450.)

Alkalies and alkalinity.—Any of the standard methods may be used both for the alkalies and for the alkalinity of the ash of the various soap preparations.

Formalin.—Employ the method of Blank and Finkenbeiner (Ber. 31, (17) (2979), of which the following is an abstract:[1]

> Three grams of the solution are weighed off into a tall Erlenmeyer flask containing 25 to 30 cc of double normal sodium hydroxid; 50 cc of pure 2.5 to 3 per cent hydrogen peroxide solution are then gradually added during a space of three minutes through a funnel placed in the neck of the flask to prevent spurting. After standing two or three minutes the funnel is washed with water and the unused sodium hydroxid titrated with double-normal sulphuric acid, using litmus as indicator.
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> When analyzing solutions containing less than 30 per cent of formaldehyde, the mixture must be allowed to stand ten minutes after adding the hydrogen peroxid to complete the reaction.

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[1] Journal of the Society of Chemical Industry, Vol. XVIII, No. 1 (Jan. 31, 1899), p. 79.

The percentage of formaldehyde is found by multiplying the number of cubic centimeters of soda solution used by 2 when 3 grams of substance are taken.

Acetaldehyde reacts much more slowly with the reagent than formaldehyde, and it is doubtful whether the reaction is quantitative. Paraldehyde reacts still more slowly with hydrogen peroxide, even in the presence of a trace of ferrous salt. Benzaldehyde is acted upon more quickly, particularly in presence of ferrous sulphate, and a considerable evolution of gas takes place, but a long time is needed to complete the reaction.

Nicotin.—No work has been done in this direction which warrants a change from the method proposed by Kissling, which was found by McElroy to be the most simple and reliable,[1] but it is suggested that the modification proposed by Prof. A. L. Winton on p. 125 of the proceedings of the last convention of this association[2] be given a comparative trial.

Arsenic.—By precipitation with hydrogen sulphid and weighing as arsenious sulphid. This method is applicable to Paris green and other compounds of arsenic with metals of Group V, except mercury. (Compare Fresenius Quant. Anal., edition of 1886, p. 350 and p. 556.) Dissolve with hydrochloric acid; heat the solution in a flask (preferably on an iron plate or similar arrangement) to about 70° C. and conduct hydrogen sulphid at the same time into the fluid as long as precipitation takes place. The precipitate formed is a mixture of sulphur and arsenious sulphid, with the sulphids of the metals of Group V. Spread out the filter in a porcelain dish with watch-glass cover, and digest over a water bath with sodium sulphid solution. Decant and repeat the digestion two or three times. Finally add some water, filter off with clear solution and wash the residue with hydrogen sulphid water. This residue is to be examined for metals of the fifth group. If only copper is present, the precipitate may be immediately dried, burned, and weighed as cuprous sulphid, as already described.

The sodium sulphid solution is warmed and made acid with hydrochloric acid, which reprecipitates the arsenious acid and a large amount of free sulphur. Filter and wash; extract the still moist precipitate on the filter with ammonia, wash the residual sulphur, reprecipitate the solution with hydrochloric acid without heat, filter on a Gooch crucible, dry, extract the remaining free sulphur with carbon disulphid, dry at 100° C. and weigh, repeating the extraction and drying until constant weight is secured. From the arsenious sulphid (As_2S_3) compute arsenious oxid (As_2O_3).

If small quantities of copper, etc., are to be separated from much arsenic, the following is a better method: Dissolve with hydrochloric acid and oxidize with potassium chlorate; then pass the hydrogen sulphid for a short time. The copper is precipitated before the arsenic begins to come down. If the latter is questioned, there is a much smaller precipitate to be extracted with a little sodium sulphid solution; the extract thus obtained is to be acidified with hydrochloric acid and added to the former filtrate containing the principal quantity of the arsenic. Then proceed to precipitate the arsenic with hydrogen sulphid.

At the conclusion of the report of the referee the president called for papers on this subject. None being presented, discussion was called for.

Professor Colby asked if the methods recommended by the referee applied to the determination of free arsenious acid.

The secretary said that no special method was given for that, but that the general method employed would be able to distinguish the free arsenious acid from the acid in combination.

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[1] Wiley, Principles and Practice of Agricultural Analysis, Vol. III, p. 606.

[2] Bull. 56, Division of Chemistry, U. S. Dept. of Agriculture.

Mr. Kilgore. I will say a few words in regard to the existence of free arsenic in insecticides. The best work which this association could do would be to determine the definite form of the compounds in the arsenical insecticides. The foliage of plants, as is well known, is injured by soluble arsenical compounds, such as free arsenic, whereas the insoluble compounds do not in any way injure the leaves. For instance, the arsenic in London purple is partly soluble, especially when the London purple is made as a by-product in the manufacture of aniline. Wherever there is any suspicion of the presence of free arsenical compounds it is advisable to treat the insecticide with lime before use; this treatment producing an insoluble arsenical compound of lime. I have found that in the substance sold as London purple there is a residue from the manufacture of aniline that is a rose aniline compound of arsenic which is soluble in water. The addition of lime decomposes this soluble compound and makes an arsenate of lime which is innocuous, so far as the foliage is concerned, yet deadly to insects.

Professor Blouin stated that Louisiana had a law regulating the sale of Paris green, and requiring that there should be a minimum content of arsenic of 50 per cent. He had the suspicion that phosphoric acid was sometimes added as a substitute for arsenic, since some of the methods of precipitation of arsenic precipitated also phosphoric acid as a simple compound. This was especially true of precipitates formed by molybdic acid and its compounds. He briefly described the methods of analysis employed by him in the work in Louisiana.

Mr. Shaw.' The Oregon station has done a limited amount of work upon insecticides, principally upon Paris green and the relative alkalinity of commercial concentrated lyes. Our examination of the Paris green sold in our markets shows that about 44 per cent was below standard. The most common adulterant proved to be gypsum. There was a wonderful difference in the physical appearance even of the material which was up to standard. That in which the granules were small was always of a paler color than when the granules were large. In some of the Paris greens of our market there were, without doubt, evidences of considerable free arsenic which, while it might add to its poisonous qualities, would also give greater tendency to burn the foliage and therefore render a condition of that kind undesirable. We have obtained good results by oxidizing with potassium chlorate removing chlorin and precipitating with magnesia mixture after making alkaline with ammonia. It was found necessary to be very careful in the removal of the chlorine before adding the precipitating reagent. We also found it necessary to moisten the filter paper with a solution of ammonium nitrate before burning. Our work on concentrated commercial lyes has not been done in the way of complete analysis, but rather confined to the total alkalinity or the amount of pure alkali to the pound of lye. We have found a wonderful variation not only from the strength which might be expected from a good quality of lye, but also strength claimed by manufacturers.

The president called attention to the use of insecticides in Michigan, and stated that injury to the foliage by the use of soluble arsenical compounds had frequently been observed. He described briefly the methods of preparing the lime insecticides.

The recommendations of the referee on fungicides and insecticides were referred to the committee on recommendations, with request to report before the adjournment of the morning session.

The report of the referee on dairy products was then called for.

The referee, Mr. J. B. Weems, not being present, his report was read by the secretary, as follows:

REPORT OF REFEREE ON DAIRY PRODUCTS FOR 1899.

By J. B. Weems, *Referee.*

In reviewing the work of the association relating to the investigation of subjects connected with dairy products one finds that the first report on the subject was made by Dr. H. W. Wiley as reporter, at the fourth convention in 1887. The work of this year consisted in the comparison of the results from eight analysts who tested four samples of butter, butterine, and oleomargarine sent to them by the reporter. The tests made upon the samples were the determination of specific gravity, melting point, volatile acids, soluble acids, insoluble acids, salt, and curd.

In 1888 Dr. Wiley was again the reporter on this subject. The report was a résumé of the work during the year, as no samples were sent out to the members of the association.

At the annual convention in 1889 Dr. Wiley made his third report as reporter on dairy products. The work of this year consisted in the examination of one sample each of oleomargarine, butterine, and butter. The results of the determination of the specific gravity, melting point, and volatile acids were received from twenty-two analysts and compared in this report.

Dr. E. H. Jenkins was the reporter on dairy products at the convention in 1890, and in his report it is found that eleven analysts made determinations of water, casein, fat, ash, and salt in one sample of creamery butter sent to them.

In 1891 Prof. W. W. Cooke was the reporter. The work of the year was upon the determination of solids, fat, casein, sugar, and ash, in one sample of milk. Results were received from ten chemists, and in their work the analysts made determinations of solids in the milk by drying at a temperature of 100° and 105° with sand and asbestus. The amount of fat obtained by drying on paper, sand, and asbestus, and then extracting with ether were compared, also the results obtained by the Babcock, Parsons, and Beimling methods.

At the ninth convention Prof. S. M. Babcock made the report for the year, and consideration was given to the following:

(1) The comparison of the results obtained by the Leffman-Beam method of saponification with those obtained by the official method.

(2) The comparison of the results obtained by using glass and block-tin condensers in the determination of volatile acids in butter fat.

(3) The necessity of melting the free fatty acids before distillation.

(4) The comparison of methods of cheese analysis.

During this year no samples were sent out by the reporter. Results were received from five chemists. These results indicated that in the comparison of the Leffman-Beam method with the official, the Leffman-Beam method gave results which were 0.84 cc lower than the official method. The results obtained from the use of glass and block-tin condensers indicated that the results obtained with the block-tin condenser were lower than those with the glass condenser. No definite conclusion was reached on the question of melting the free fatty acids before distillation.

The work on the methods of cheese analysis included a comparison of the results obtained in drying cheese over sulphuric acid and at 100°, the drying of the extracted residue over sulphuric acid and at a temperature of 100°, and a comparison of results obtained by the Babcock and Short methods. The report made at the tenth convention in 1893 was by Mr. A. L. Winton and consideration was given to the following subjects:

(1) The drying of cheese and ether extract in air and hydrogen.

(2) The determination of solids and fat in milk by means of asbestus in a perforated metal cylinder.

(3) The comparison of results obtained by the direct determination of solids in milk and the calculation of the same from the specific gravity and the percentage of fat.

In the investigation of the methods of drying cheese it was found that the results were about the same when dried in air and hydrogen. Some of the samples were found to lose weight when dried for forty hours, while most of the water was lost in four hours. The method of drying milk on asbestus in a perforated cylinder for the determination of solids and the extraction of the same for the fat is summed up in the report with the statement "for simplicity and convenience the cylinder method can hardly be equaled." The results obtained from extracting the solids of milk dried in air and hydrogen were practically the same. The result of the investigation on the comparison between the direct determination of solids in milk and that calculated from the specific gravity and the percentage of fat showed that the formula of Hehner and Richmond gave the most satisfactory results.

Prof. E. H. Farrington was the reporter on dairy products at the eleventh annual convention. The work of this year was a repetition of a part of the work of the previous year and consisted of a comparison of the results obtained by the direct determination of solids in milk with those calculated from the specific gravity and the percentage of fat by the formulas of Fleischmann, Babcock, Hehner and Richmond, and Richmond. In addition to this work there was an investigation in which the results obtained by extracting the fat of milk dried on sand and asbestus were compared with the results obtained by the Babcock method. The result of the work of the year showed that the comparison between the direct determination of solids in milk and the calculation from the specific gravity and percentage of fat was in favor of the formula of Hehner and Richmond. The comparison of the results obtained by the usual gravimetric methods with those from the Babcock method in the determination of fat in milk resulted in a very satisfactory manner. In a series of experiments to determine whether there is any loss of fat in the souring of milk, it was found that there was practically no loss when milk had been kept for three months.

In the investigation of the question whether the solids of milk change when allowed to sour on sand and asbestus, it was indicated that "there was a decrease from day to day in the percentage of solids and ether extract found in milk weighed and allowed to sour on sand, while in that treated in the same manner with asbestus the decrease was much smaller."

Prof. E. H. Farrington was the referee on dairy products for the second time at the annual convention in 1895. A circular letter was sent to fifty chemists, in which the suggestion was made that "it is your reporter's opinion that more and better work may be done if each chemist will send to him, on or before August 1, 1895, a report on some work of his own selection, rather than for me to attempt to supply samples and directions for investigations."

The topics to which attention was invited by the referee were as follows:

Cheese analysis:

I. Fat
  1. By the Babcock test.
  2. By drying at 100° C. and extracting.
  3. By provisional method adopted.
  4. By modification of provisional method adopted.

II. Determination of acid in cheese.
III. Determination of different classes of nitrogen compounds.

The determination of albuminoids in milk:

I. What is the correct factor for casein and albumin?
II. Does the Ritthausen method precipitate all the albuminoids and in a state of purity?
III. How are the casein and albumin best determined separately?
IV. What is the amount of nonalbuminoid nitrogen in milk?

There was only one result from the letter of the reporter, and that was a communication from Prof. S. M. Babcock on the comparison of results from the direct determination of solids in milk and the calculations of the same from the specific gravity and percentage of fat.

The reporter for the thirteenth annual convention was Dr. L. L. Van Slyke. In the work of this year consideration was given to the analysis of cheese, and special attention to the preparation of sample and determination of fat, and some study of the acidity of cheese.

The following methods for the determination of fat in cheese were considered:

I. The present provisional method (1895).
II. The same, modified.
III. The extraction of fat after drying.
IV. The Babcock test.

The provisional method was at that time, stated briefly, as follows: "The sample of cheese was ground with about twice its weight of anhydrous copper sulphate and then extracted with ether." The proposed modification had for its object the prevention of possible loss of fat, by grinding the weighed sample after most of the fat had been extracted.

The extraction after drying was as follows: Weigh out 2 to 5 grams of cheese, dry at a temperature of boiling water for ten hours, then extract with ether. After five hours remove the cheese and grind with some incinerated sand. Replace in flask and continue extraction for ten hours longer. The results obtained from the work of three chemists were as follows:

	Per cent.
Provisional method	38.55
Provisional method modified	39.23
Extraction after drying	39.69
Babcock test	39.81

The results of the work as a whole indicated that in the extraction methods the fat of cheese is not entirely extracted.

The report on dairy products at the fourteenth annual convention was made by Dr. L. L. Van Slyke as referee. This report was limited to the determination of casein and albumin in milk. As a result of the work of the year the referee made a number of recommendations, among which were the following:

1. That the provisional method for determining casein in cow's milk be made official.

2. That the modified provisional method for determining albumin in cow's milk be

substituted as a provisional method for the present provisional method, and that further cooperative work be done on the determination of albumin.

3. That the magnesium sulphate method for determining casein in cow's milk be made an official optional method.

In addition to the report on the investigation of methods for the determination of casein and albumin in cow's milk, the referee considered the question of adulteration in dairy products, and called especial attention to the methods for the detection of adulteration in milk, butter, and cheese.

Prof. C. L. Penny made the report on dairy products as referee at the fifteenth annual convention in 1898. The work of the year was a continuation of the study of methods for the determination of casein and albumin in milk and the comparison of methods for the determination of volatile acids in butter, as follows:

1. Compare the provisional method of saponification, using a reflux tube or condenser (Circular 4, p. 3), with the official method prescribing a closed flask.

2. Compare with the official method of saponification the Leffman-Beam method, using, if possible, both fresh and rancid butter. (See Analyst, Vol. XVI, p. 153; Vol. XVII, pp. 65 and 176, and Vol. XXI, p. 259.)

The results of the investigation of the methods of saponification as outlined above were very satisfactory, as shown by the recommendations of the referee.

In connection with the reports of the referees made at the annual conventions, there have been a number of papers presented by members of the association, on subjects connected with the investigation of dairy products, and in this connection the following list of papers may be of interest:

The fourth report contains "Average of analyses of American butters," by Edgar Richards, and "Variations in the composition of butter," by S. M. Babcock. The fifth report contains "The milk of Washington not normal," by C. Richardson; "Notes on the method for soluble and insoluble fat acids," by G. E. Patrick, and "Refractive index of butter fat," by H. W. Wiley.

The eighth report has two papers, one by W. W. Cooke, on the "Analysis of sour milk," and the other by G. E. Patrick, on "Composite milk samples in the laboratory." In the tenth report, we find "The determination of casein in cow's milk," "The determination of fat in cheese," and "The determination of acidity in milk," by L. L. Van Slyke, and "The determination of solids and fat in milk by drying with asbestus in a perforated metal cylinder," by A. L. Winton.

The eleventh report contains "The determination of albumin in cow's milk," by L. L. Van Slyke, "Does cream lose fat on keeping a long time with and without bichromate of potash?" "A method of determining butter fat in milk or cream by difference," and an abstract of an article on "The calculation of total solids in milk from the per cent of fat and the specific gravity, according to the formulas of Babcock, Fleischmann, and Hehner and Richmond, compared with the gravimetric method," by L. L. Van Slyke.

The twelfth annual report has a paper by C. G. Hopkins and W. A. Powers "On the determination of the acidity of milk and cream."

In the thirteenth report there is found a paper by J. M. Bartlett entitled "A modification of the Babcock method and apparatus for testing milk and cream."

Report for 1899.—As the results of suggestions made by Dr. L. L. Van Slyke and Prof. C. L. Penny, it was decided to repeat the work of last year and in addition compare the results from a method proposed by the referee of last year.

The following letter was sent to the chemists connected with the experiment stations:

> DEAR SIR: As referee on dairy products of the association, I would be very glad to have you cooperate in the work of this year. Should you find it convenient to aid in the work kindly let me know, and samples will be sent at any time that is the most convenient to you.
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> Yours, very respectfully, J. B. WEEMS.

To those who were willing to aid in the work, a sample of skim milk, containing formaldehyde to preserve it, was sent with the following outline of the methods for comparison:

ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS.

METHODS OF THE ANALYSIS OF DAIRY PRODUCTS.

Your cooperation is respectfully requested in a comparison of the following methods for the determination of casein and albumin in milk:

I. *Casein in milk:*

(1) Modification of provisional method. (Acetic acid method. Circular 4, p. 3.) "Carry the method through as described to the washing of the precipitate, then neutralize the filtrate as exactly as possible with caustic alkali, then filter off any precipitate that may form and add it to the former precipitate for the nitrogen determination."

(2) Alum method. "To 10 cc of milk add 50 cc of water at 40°. Then add 1.5 cc of alum solution saturated at 40° or higher. If the precipitate fails to settle promptly, add 0.5 cc more of the alum solution, filter, wash with water, and use the Kjeldahl method for the determination of nitrogen."

II. *Albumin in milk:*

Modification of provisional method: "To the filtrate from the casein, according to either of the above methods, add 10 cc of strong tannin solution; heat, filter, wash with water, and determine nitrogen."

III. Dilute 60 cc of milk with 300 cc of distilled water in a 500 cc measuring flask, then add 10 cc of alum solution (see (2) alum method) to precipitate the casein, and fill to the mark. Filter off 50, 100, or 200 cc, as may be desired, and determine the nitrogen in the usual manner. Multiply the result by 6.25. Determine the total nitrogen in the sample of milk and multiply by 6.25 for total nitrogenous compounds present in the milk. From the result obtained for total nitrogenous compounds subtract the result obtained from the filtrate, and consider the difference as casein.

Methods I and II are a continuation of the work of last year. III is the method recommended by Mr. C. L. Penny as referee in his report of last year. In reporting results, kindly send all necessary data in order that full comparisons may be made.

J. B. WEEMS, *Referee.*

AMES, IOWA.

In connection with the above circular and for the convenience of those aiding in the work, it was decided to prepare three samples of skim milk to which enough formaldehyde was added to preserve the samples for the time necessary for transportation and analysis. Two of the samples were sent to the chemists connected with other stations, and the other kept for analysis in the station laboratory. Sample 1 was sent to six stations and sample 3 to five stations. To the present time returns have been received from eight stations, and with the work of this station are as follows:

SAMPLE NO. 1.

Analyst.	Casein.		Albumin.		Penny's method.		
	Modification of provisional method.	Alum method.	Modification of provisional method.	Alum method.	Total nitrogen × 6.25.	Casein.	Nitrogen in filtrate × 6.25.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
W. H. Heileman, Washington..	2.377	2.300	0.445	0.471	3.080	2.547	0.533
C. L. Penny, Newark, Del......	2.300	2.320	.460	.560	3.050	2.310	.740
W. B. Cady, Missouri...........	2.340	2.294	.515	.564	3.052	2.233	.810
Maurice Bird, Louisiana.......	2.450	2.410	....	.460	3.030	2.520	.490
J. A. LeClerc, Geneva, N. Y....	2.390	2.340	.350	.460	3.030	2.380	.650
I. J. Mead, Ames, Iowa.........	2.160	2.190	.554	.533	2.912	2.079	.810
Highest..................	2.450	2.410	.554	.564	3.080	2.547	.810
Lowest	2.160	2.190	.350	.460	2.912	2.079	.490
Average	2.336	2.309	.4650	.508	3.0260	2.3450	.672

SAMPLE NO. 2.

Analyst.	Casein.		Albumin.		Penny's method.		
	Modification of provisional method.	Alum method.	Modification of provisional method.	Alum method.	Total nitrogen × 6.25.	Casein.	Nitrogen in filtrate × 6.25.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
I. J. Mead, Iowa	2.422	2.442	0.484	0.494	3.21	2.325	0.885
H. N. Grettenberg, Iowa	2.458	2.448	.516	.496	3.31	2.280	1.030
J. C. Brown, Iowa	2.488	2.426	.467	.540	3.25	2.252	.998
Highest	2.488	2.448	.516	.540	3.31	2.325	1.030
Lowest	2.422	2.426	.467	.494	3.21	2.252	.885
Average	2,456	2.438	.489	.510	3.26	2.283	.971

SAMPLE No. 3.

Analyst.	Casein.		Albumin.		Penny's method.		
	Modification of provisional method.	Alum method.	Modification of provisional method.	Alum method.	Total nitrogen × 6.25.	Casein.	Nitrogen in filtrate × 6.25.
N. E. Wilson, Nevada	2.627	2.594	0.532	0.599	3.358	2.662	0.681
	2.627	2.594	.532	.599	3.358	2.662	.681
	2.627	2.594	.532	.599	3.358	....	....
	2.594	2.627	....	.632	....	....	....
	2.594	2.627	....	.632	....	....	....
	2.614	2.604	.532	.608	3.358	2.662	.681
O. W. Knight, Maine	2.690	2.630	.440	.560	3.380	2.940	.440
	2.630	2.560	....	.560	3.380	2.940	.440
	2.660	2.595	.440	.560	3.380	2.940	.440
A. J. Patten, Maine	2.620	2.560	....	.530	3.380	2.570	.810
	2.620	2.620	....	.520	3.440	2.630	.810
	2.620	2.590	....	.525	3.410	2.600	.810
E. W. Woll and Alfred Vivian, Wisconsin	2.670	2.670	.508	....	3.240	2.454	.786
	2.550	2.650	.549	....	3.390	2.603	.787
	2.590	2.620	.519	....	3.330	2.543	.787
		2.640					
	2.600	2.650	.525	....	3.320	2.533	.787
I. J. Mead, Iowa	2.489	2.479	.483	.530	3.300	2.501	.799
H. N. Grettenberg, Iowa	2.537	2.530	.522	.495	3.219	2.500	.719
J. C. Brown, Iowa	2.505	2.542	.456	.476	3.220	2.410	.810
Highest	2.660	2.650	.5323	.608	3.410	2.940	.810
Lowest	2.489	2.479	.440	.476	3.219	2.410	.440
Average	2.575	2.570	.492	.532	3.315	2.593	.720

If the results from the three samples be compared, we have the following:

	Modification of provisional method.	Alum method.	Penny's method.
Casein.	*Per cent.*	*Per cent.*	*Per cent.*
Sample 1, average of 6 results	2.336	2.309	2.344
Sample 2, average of 3 results	2.466	2.438	2.282
Sample 3, average of 7 results	2.575	2.570	2.598
Average of the 3 samples	2.459	2.436	2.406
Albumin.			
Sample 1, average of 6 results	0.464	0.508	0.672
Sample 2, average of 3 results	.489	.510	.971
Sample 3, average of 7 results	.492	.532	.721
Average of the 3 samples	.4816	.5166	.787

As a result of the sixteen analyses of the three samples of milk we find in the determination of casein that there is a difference in the results of the modification of the provisional method and the alum method of 0.023 per cent, while the difference between the albumin results in the two methods is 0.035 per cent.

The time for the work of investigation being so short this year, the referee would prefer not to make any recommendations, but would suggest a continuation of the work next year, with the addition of other methods, in order that the subject may be investigated in a thorough manner and be made as complete as possible.

The president called for papers on this subject and also for discussion. Since the report contained no recommendations save that the work be continued along the same lines for another year, it was not referred to the committee on recommendations.

The president next called for the report of the committee on recommendations. Mr. C. D. Woods, the chairman of the committee, presented the report orally. Very few recommendations had been made by the referees, so that the work of the committee was comparatively light. In regard to the recommendations of the referee on fungicides and insecticides it was recommended that the methods of analysis, although not perfect, be suggested tentatively for the use of the members of the association, but that they should not in any sense be designated as official.

The president asked for a vote on this recommendation and it was unanimously adopted.

The recommendation of the referee on potash, with a slight modification of the method of solution, was recommended for further study, but not for adoption.

The report of the committee on recommendations was adopted without change.

The report of the abstract committee was next presented by Mr. Allen, and on motion was accepted.

REPORT OF THE COMMITTEE ON ABSTRACTING.

MR. PRESIDENT AND MEMBERS OF THE ASSOCIATION: The work of this committee was organized with as little delay as possible after its designation, and the following letter sent out by the chairman:

WASHINGTON, D. C., *January 16, 1899.*

——— ———,
——— ———.

DEAR SIR: On account of several changes in the abstract committee since its designation at the meeting last November it has only just become possible to make an assignment of work for the year. This assignment, which I hope will prove agreeable to the members of the committee, I have made as follows:

E. W. Allen: Jour. Landw.; Milch Ztg.; abstracts in Analyst, Chem. Centrbl., Chem. Ztg. Repert.
J. T. Anderson: Chem. Ztg.; Jour. Chem. Soc. [London].
W. H. Beal: Compt. Rend.; Bul. Soc. Chim. Paris; Ztschr. Angew. Chem.; abstracts in Jour. Chem. Soc. [London].
E. B. Holland: Amer. Chem. Jour.; Analyst.
C. G. Jentner: Ztschr. Untersuch. Nahr. u. Genussmtl.; Ztschr. Physiol. Chem.
L. H. Merrill: Jour. Amer. Chem. Soc.; Jour. Franklin Inst.
Harry Snyder: Bul. Assoc. Belge Chim.; Rev. Chim. Analyt. et Appl.; Ann. Sci. Agron.
J. B. Street: Landw. Vers. Stat.; Ztschr. Analyt. Chem.
C. B. Williams: Jour. Soc. Chem. Ind.; Chem. News.

In taking up the work please begin with the numbers of the journals which you have received since January 1, 1899. It is very important that the journals should be followed systematically, otherwise important articles may fail of notice in the Experiment Station Record. To avoid this and to keep the work up to date, it has seemed best to have an understanding with the members of the committee that any numbers which have become two months in arrears will be abstracted in the Office of Experiment Stations—in other words, that if by force of circumstances you are prevented from abstracting your journals for a period you will know that any journals which you have had on hand for two months or more have been attended to in this office, and be governed accordingly in resuming the work. The cooperation of all members of the abstract committee is earnestly desired, and the object of the above arrangement is, as explained, merely to prevent any gaps in the work.

It will be understood that you are to abstract only such original articles in your journals as relate to methods and apparatus for agricultural analysis, not articles on general or industrial chemistry. For the form of statement of the abstract see Experiment Station Record. In giving the reference please state the name of the periodical, using the abbreviations given above, the volume number in figures, the year in parentheses, the number within the volume (No., Heft, Fasc., etc.), and the pages (beginning and end of the article) with the number of figures. Please take pains to give full references and to write all names and technical terms plainly. The abstracts should be signed by the abstracter.

I send you herewith a supply of franked envelopes to be used in sending in material. Others can be procured as needed.

Very respectfully, yours,

E. W. ALLEN, *Chairman.*

The work of abstracting has gone on with regularity, the abstracts being published in the numbers of the Experiment Station Record, as heretofore. On account of the shortened period of its work, due to the holding of the meeting of the association at an earlier date than usual, the aggregate amount of matter published has not been as great as formerly, but relatively it is believed there has been no falling off.

E. W. ALLEN,
J. T. ANDERSON,
W. H. BEAL,
E. B. HOLLAND,
C. G. JENTNER,
L. H. MERRILL,
HARRY SNYDER,
J. B. STREET,
C. B. WILLIAMS,
Committee.

Mr. B. F. Kilgore then presented the report of the committee on volumetric standards. He remarked that this association was the first one in this country that had taken any action in regard to uniformity of standards. He had written to the secretary of the association last year in regard to bringing the action of the association before the Third International Congress of Applied Chemistry, which was held in Vienna, and he would ask the secretary later to give a brief report of what was done at that meeting. In his opinion the principal point to be considered was the fixing of a standard of temperature for this country. When in North Carolina he had found that the mean temperature of the working hours was 21.8°. In Mississippi he had made a determination of the mean temperature of the working hours for six months, and found it to be 22.9°. Often the temperature in his laboratory exceeded 30°, and this would make a great change in the volume of a liter flask.

The secretary was called upon to report briefly what was done in Vienna in regard to standards. He stated that the communication of Mr. Kilgore was brought officially before the section on standard measures for sugar analysis. Attention was called to the fact that the temperatures in the United States were often very much higher than in Europe. In the laboratory at Washington a temperature of 40° had frequently been attained.

Mr. Frear called attention to the fact that when he worked in the laboratory at Washington a temperature of more than 40° was obtained in a room where a muffle furnace was used.

The secretary stated that without any artificial heat it was not unusual in the summer time for the laboratory to be at blood heat or above. The congress at Vienna voted unanimously to adopt the absolute standard of measure, and to discontinue the use of the so-called Mohr liter as soon as possible.

The secretary said that the Mohr liter was true to name in more than one respect, since it was not only Mohr, but *more*, containing 1,002.3 cubic centimeters.

Mr. Kilgore called attention to the fact that a Mohr liter which had been standardized at a temperature of 17½° would hold nearly 4 cc more at 30° than a true liter flask at 17½°.

The secretary said that in this country we were rapidly achieving success in the manufacture of instruments of precision. We already made the best standard measurements of length in the world, and the microscopes which were made in Rochester rivaled those manufactured by Zeiss. Lately Bausch & Lomb, of Rochester, had sent to Washington a complete set of volumetric apparatus which they guaranteed to be exact. There was, however, no mark on any piece of the set which would indicate the temperature at which it was standardized, and, therefore, without recalibration such a set of apparatus would be of little utility. It was evident, the secretary said, that the standard for volumetric apparatus in this country should be fixed at a higher temperature than 17½°, and the temperature of 22° or 23° was suggested as being a convenient one.

On motion, the report of the committee on volumetric standards was accepted and the committee continued for further corroborative work.

The president then called for the report of the committee on nominations. The report was presented by the chairman, Mr. William Frear, and is as follows:

REPORT OF COMMITTEE ON NOMINATIONS.

GENTLEMEN OF THE ASSOCIATION OF OFFICIAL AGRICULTURISTS: Your committee on nominations respectfully recommend for election to the several elective offices of this association the following-named gentlemen:

For president, Mr. B. W. Kilgore, of North Carolina.

For vice-president, Mr. L. L. Van Slyke, of New York.

For secretary, Mr. H. W. Wiley, of Washington, D. C.

For additional members of the executive committee, Mr. M.E. Jaffa, of California, and Mr. Arthur Goss, of New Mexico.

Respectfully submitted.

WILLIAM FREAR, *Chairman.*

On motion, the secretary of the association was directed to cast the ballot of the association for the nominees above mentioned. The secretary thereupon cast the ballot for the association and reported the gentlemen nominated for the several offices unanimously elected thereto.

The report of the committee on food standards was then called for.

The secretary stated that as chairman of the committee he had asked Dr. Frear, who was chairman of the subcommittee on standards, to prepare and present the report, which is as follows:

REPORT OF THE COMMITTEE ON FOOD STANDARDS.

GENTLEMEN: Your committee appointed at the convention of 1897 to consider the feasibility of fixing a set of pure-food standards, and empowered at that time to institute, without further action on the part of this association, such coöperative work as it deemed wise, to the end that a set of such standards might be formulated for the adoption of the association, respectfully reports that during the past year work has been conducted along the lines indicated in the report of this committee at the meeting of 1898 (Bulletin 56, Div. of Chem., U. S. Dept. Agr., pp. 128–130). From the subcommittee appointed by this committee to consider the subject of classification and standards it is reported that Mr. A. L. Winton, of the Connecticut Station, has completed the chemical examination of a large series of imported spices sampled by him from the original packages; that Prof. F. W. Woll has completed the chemical examination of sixty samples of American and Canadian dairy and table salts, and has compiled a large number of analyses of these materials made by other chemists; that Dr. L. L. Van Slyke has gathered most of the material needful for the fixing of standards for American dairy products; that Dr. J. B. Lindsey, whose serious illness has prevented the formulation of his report, has gathered much of the data needful for the formulation of standards for grains and their products, including cattle foods; that Prof. M. A. Scovell reports the accumulation of most of the needful data for standards for sugars and related substances; that Prof. H. A. Huston reports that he has gathered together much of the needful evidence respecting substances artificially introduced with possible injury to health; that Prof. William Frear has made a considerable number of analyses of vinegars, and compiled data upon that subject.

The rather short notice of the present meeting and the unusually brief interval that has elapsed since the last meeting have made the completion of the work of your committee to the point of formulating a set of standards for your consideration at this time impracticable. The work has, however, so far advanced that, in the judgment of your committee, it will be possible within a very short time to formulate, under certain broad canons of standardization, a set of standards for the more important foods of man and domestic animals.

Since the last meeting of this association the Congress of the United States, in considering that national measure for the prevention of misbranding and adulteration of foods and drugs indorsed by the National Pure Food and Drug Congress, and known in the United States Senate as the Faulkner bill, and in the United States House of Representatives as the Brosius bill, has, through its favorable report by the Committee on Agriculture of the Senate, and the favorable consideration by the House Committee on Interstate Commerce, distinctly indicated this association as the proper official advisory body with reference to the chemical aspects of food standards. It has been suggested by legal authorities in Congress that, in view of prospective early legislation for the establishing of national control of interstate commerce in foods and drugs, it is highly desirable that this association should, as promptly as existing information may make it possible to fix standards of strength and purity, prepare and publish such a set of standards to serve as a guide in the case of foods, just as the United States Pharmacopœia does in the case of drugs, since reference to such standards in the course of the legislation indicated may prove desirable.

In view of the present forward condition of the work assigned to it, so far as it affects the formulation of standards, and of the present need for the adoption of a set of such standards, your committee respectfully recommends that it be authorized to prepare and publish in the name of this association, and as soon after this meeting as it is found practicable, a set of such standards as it can satisfactorily formulate.

Respectfully submitted.

H. W. Wiley,
W. H. Scovell,
E. H. Jenkins,
William Frear,
Committee.

July 6, 1899.

The secretary said, in discussing the report of the committee, that the matter under consideration was one of the greatest importance which had ever come before the association. The importance of fixing standards of value for human foods was a work of great magnitude and of the highest significance from a legal aspect. The people of this country not only were entitled to protection against fraud in foods, but in order to preserve our foreign markets it is absolutely necessary that a system of national inspection be inaugurated. The nations of Europe are constantly seeking some pretext to close their markets against American food products. If commerce in adulterated foods be allowed to go on unrestricted in this country, the nations of Europe may have an apparently just cause for such exclusion. If the nations of Europe levy a duty on food products sent to their country, no just cause of complaint exists, because this duty rests equally upon all outside nations. When, however, a discrimination is made against the products of one country on the ground that they are injurious to health or adulterated, such discrimination becomes unbearable when the facts of the case do not justify it. An instance of this is seen in the closing, or partial closing, of the German markets to American pork. Dr. Stiles, the agricultural attaché of the American legation at Berlin, has investigated all the cases of trichinosis which have been reported since his residence in Berlin. In every case he found that the allegation that the attack was caused by American pork was false. In not a single instance had any American pork been eaten. It is evident, therefore, that the exclusion of our meat products on the alleged ground that they contain trichinæ is an unjust discrimination. Lately hundreds of newspapers in Europe have published a statement, attributed to me, that 90 per cent of all the food products of this country are adulterated. This statement arose from my testimony before the Senate Committee on Commerce in Chicago to this effect, namely, that 90 per cent of all food products had at some time or other been the subject of adulteration. Thus every possible pretext for excluding American food products is employed to our disadvantage. The Congress of the United States has officially recognized this association as the authority on the subject of adulterated foods and food standards. It is therefore of the utmost importance that the labors of the committee be completed at as early a date as possible. To this end I venture to ask this association to authorize this committee to complete its report, and that when its report is finished it be published and accepted as the official action of this association.

Mr. Jenkins offered the following resolution:

Resolved, That the report of the committee on food standards, as soon as completed, be accepted by this association and referred to the executive committee, and when indorsed by the executive committee be accepted as the authoritative report of this association.

The motion was unanimously carried.

The reports of the committees on rewriting methods of soil analysis and on rewriting Bulletin No. 46, were presented, as follows:

REPORT OF THE COMMITTEE ON REWRITING METHODS OF SOIL ANALYSIS.

The committee on the rewriting of methods of soil analysis begs to report that the methods of soil analysis were rewritten by the secretary in harmony with the authorization given at the last meeting of the association, and are published as a part of Bulletin No. 46 (revised).

Respectfully,

M. A. Scovell,
A. M. Peter,
H. W. Wiley,
Committee.

REPORT OF THE COMMITTEE ON THE REWRITING OF BULLETIN NO. 46.

I beg to submit the following report:

The whole of Bulletin No. 46 was carefully revised and rewritten, inserting the various amendments which have been made from time to time during the past three years, condensing the methods of analysis in some cases and slightly changing the phraseology in others, without, however, making alterations in the methods themselves, as ratified by the association, as a whole or in part. A large number of members were consulted by correspondence and otherwise in the revision of the work.

Bulletin No. 46, revised, is now offered as a full report of this committee.

Respectfully,

H. W. Wiley, *Committee.*

The secretary offered the following resolution:

Resolved, That the thanks of this association be extended to the various committees who have been instrumental in entertaining the Association of Official Agricultural Chemists during its meeting here, and especially to Mr. M. E. Jaffa, who has so earnestly and faithfully labored to make our entertainment pleasant, and our stay an agreeable one.

The resolution was unanimously adopted, and the secretary was authorized to make suitable acknowledgments in writing for the many courtesies the associations had received.

The secretary offered the following resolution:

Resolved, That the thanks of this association are hereby tendered to our retiring president, Dr. R. C. Kedzie, for the faithful and efficient manner in which he has discharged the duties of his position, and especially for the able and eloquent address which he delivered as president of the association.

Mr. B. W. Kilgore, the president elect, presented this motion to the association, and it was unanimously adopted.

The president then called upon the president elect for any announcements which he might have to make in regard to the appointment of referees and committees.

The president elect (Mr. Kilgore) stated that he had not had time to consider the matter, and therefore was unable to make any announcements at present. He would carefully consider all questions, and especially the resolution which had been passed recommending him to continue the referees and associate referees without change. In so far as this could be accomplished he would do so. He would communicate to the secretary later the names of the referees, associate referees, and the various committees authorized by the constitution and by resolution.

There being no further business, the association adjourned at 12.30 o'clock, subject to the call of the executive committee.

OFFICERS, REFEREES, AND COMMITTEES OF THE ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS FOR THE YEAR 1900.

President.

Mr. B. W. Kilgore, Raleigh, N. C.

Vice-President.

Mr. L. L. Van Slyke, Geneva, N. Y.

Secretary.

Mr. H. W. Wiley, Washington, D. C.

Additional Members of Executive Committee.

Mr. M. E. Jaffa, Berkeley, Cal.
Mr. Arthur Goss, Mesilla Park, N. Mex.

Referees.

Phosphoric acid.—Mr. E. G. Runyan, Washington, D. C.
Nitrogen.—Mr. F. S. Shiver, Clemson College, S. C.
Potash.—Mr. B. B. Ross, Auburn, Ala.
Soils.—Mr. B. L. Hartwell, Kingston, R. I.
Dairy products.—Mr. J. B. Weems, Ames, Iowa.
Foods and feeding stuffs.—Mr. Thorn Smith, Moscow, Idaho.
Liquor and food adulteration.—Mr. H. A. Weber, Columbus, Ohio.
Sugar.—Mr. R. E. Blouin, New Orleans, La.
Tannin.—Mr. Oma Carr, Lynchburg, Va.
Insecticides.—Mr. E. A. de Schweinitz, Washington, D. C.
Ash.—Mr. A. E. Shuttleworth, Guelph, Canada.

Associate Referees.

Phosphoric acid.—Mr. H. K. Miller, Lake City, Fla.
Nitrogen.—Mr. W. R. Perkins, Agricultural College, Miss.
Potash.—Mr. L. S. Munson, Washington, D. C.
Soils.—Mr. M. E. Jaffa, Berkeley, Cal.
Dairy products.—Mr. F. W. Woll, Madison, Wis.
Foods and feeding stuffs.—Mr. C. A. Browne, jr., State College, Pa.
Liquor and food adulteration.—Mr. W. D. Bigelow, Washington, D. C.
Sugar.—Mr. G. L. Spencer, Washington, D. C.
Tannin.—Mr. E. J. Haley, Ridgway, Pa.
Insecticides.—Mr. L. A. Voorhees, New Brunswick, N. J.
Ash.—Mr. G. S. Fraps, Raleigh, N. C.

ABSTRACT COMMITTEE.

Mr. E. W. Allen, Washington, D. C., chairman.
Mr. W. H. Beal, Washington, D. C.
Mr. G. W. Shaw, Corvallis, Oreg.
Mr. J. T. Anderson, Auburn, Ala.
Mr. J. P. Street, New Brunswick, N. J.
Mr. W. F. Hand, Agricultural College, Miss.
Mr. R. E. Blouin, New Orleans, La.
Mr. Harry Snyder, St. Anthony Park, Minn.
Mr. C. B. Williams, Raleigh, N. C.

COMMITTEE ON FOOD STANDARDS.

Mr. H. W. Wiley, Washington, D. C., chairman.
Mr. H. A. Weber, Columbus, Ohio.
Mr. M. A. Scovell, Lexington, Ky.
Mr. E. H. Jenkins, New Haven, Conn.
Mr. William Frear, State College, Pa.

COMMITTEE ON FERTILIZER LEGISLATION.

Mr. H. W. Wiley, Washington, D. C., chairman.
Mr. B. W. Kilgore, Raleigh, N. C.
Mr. H. B. McDonnell, College Park, Md.
Mr. H. A. Huston, Lafayette. Ind.
Mr. B. B. Ross, Auburn, Ala.

COMMITTEE ON VOLUMETRIC STANDARDS.

Mr. B. W. Kilgore, Raleigh, N. C., chairman.
Mr. C. L. Penny, Newark, Del.
Mr. E. E. Ewell, Washington, D. C.
Mr. G. C. Caldwell, Ithaca, N. Y.
Mr. H. W. Wiley, Washington, D. C.

CONSTITUTION OF THE ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS.

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(1) This association shall be known as the Association of Official Agricultural Chemists of the United States. The objects of the association shall be (1) to secure uniformity and accuracy in the methods, results, and modes of statements of analysis of fertilizers, soils, cattle foods, dairy products, and other materials connected with agricultural industry; (2) to afford opportunity for the discussion of matters of interest to agricultural chemists.

(2) Analytical chemists connected with the United States Department of Agriculture, or with any State or national agricultural experiment station or agricultural college, or with any State or national institution or body charged with official control of the materials named in section 1, shall alone be eligible to membership; and one such representative for each of these institutions or boards, when properly accredited, shall be entitled to enter motions or vote in the association. Only such chemists as are connected with institutions exercising official fertilizer control shall vote on questions involving methods of analyzing fertilizers. Any person eligible to membership may become a member at any meeting of the association by presenting proper credentials and signing this constitution. All members of the association who lose their right to such membership by retiring from positions indicated as requisite for membership shall be entitled to become honorary members, and to have all privileges of membership, save the right to hold office and vote. All analytical chemists and others interested in the objects of the association may attend its meetings and take part in its discussions, but shall not be entitled to enter motions or vote.

(3) The officers of the association shall consist of a president, a vice-president, and a secretary, who shall also act as treasurer; and these officers, together with two other members to be elected by the association, shall constitute the executive committee. When any officer ceases to be a member by reason of withdrawing from a department or board whose members are eligible to membership, his office shall be considered vacant, and a successor may be appointed by the executive committee, to continue in office till the annual meeting next following.

(4) There shall be appointed by the president, at the regular annual meeting, a referee and associate referee for each of the subjects to be considered by the association.

It shall be the duty of these referees to prepare and distribute samples and standard reagents to members of the association and others desiring the same; to furnish blanks for tabulating analyses, and to present at the annual meeting the results of work done, discussion thereof, and recommendations of methods to be followed.

(5) The special duties of the officers of the association shall be further defined, when necessary, by the executive committee.

(6) The annual meeting of this association shall be held at such place as shall be decided by the association, and at such time as shall be decided by the executive committee, and announced at least three months before the time of meeting.

(7) No changes shall be made in the methods of fertilizer analyses, except by unanimous consent, until an opportunity shall have been given all official chemists having charge of fertilizer work to test the proposed changes.

(8) Special meetings shall be called by the executive committee when in its judgment it shall be necessary, or on the written request of five members; and at any meeting, regular or special, seven enrolled members entitled to vote shall constitute a quorum for the transaction of business.

(9) The executive committee will confer with the official boards represented with reference to the payment of expenses connected with the meetings and publication of the proceedings of the association.

(10) All proposed alterations or amendments to this constitution shall be referred to a select committee of three at a regular meeting, and after report from such committee may be adopted by the approval of two-thirds of the members present entitled to vote.

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